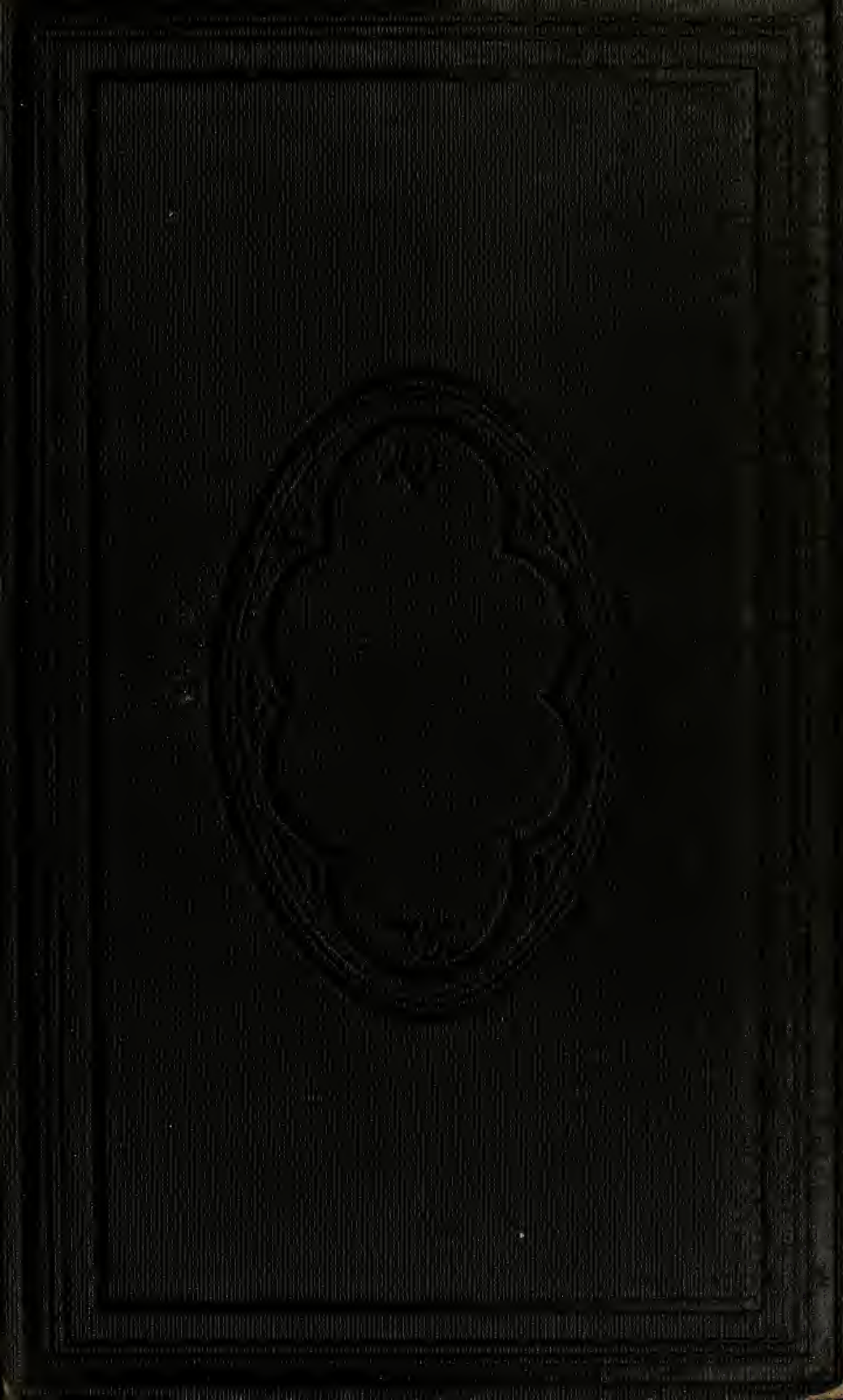






INDEX MAP

SHOWING THE PRINCIPAL RIVER
BASINS WITHIN THE STATE

of
Massachusetts.

Note. The River-Basins which have been specified
are colored green.—The details
shown.



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SEVENTH ANNUAL REPORT

OF THE

STATE BOARD OF HEALTH

OF

MASSACHUSETTS.

JANUARY, 1876.

BOSTON:
WRIGHT & POTTER, STATE PRINTERS,
79 MILK STREET (CORNER OF FEDERAL).

1876.

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ERRATA.

Page 304, line 13, for "serious," read "series."

Page 338, line 3 from bottom, for "12,050," read "12,590."

Page 338, line 2 from bottom, for "87,950," read "87,410."

Page 384, line 13, for "acts," read "facts."

Page 394, line 2, for "four," read "three."

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Commonwealth of Massachusetts.

STATE BOARD OF HEALTH, STATE HOUSE, January 27, 1876.

HON. GEORGE B. LORING, *President of the Senate of Massachusetts.*

SIR:—I have the honor to present to the legislature the Seventh Annual Report of the State Board of Health of Massachusetts, including the special report of the investigations ordered by chapter 192 of the Acts and Resolves passed by the general court of Massachusetts in the year 1875, in regard to the correct methods of drainage and sewerage of the cities and towns of the Commonwealth, especially with reference to the protection of the rivers, estuaries and ponds of the State from pollution.

Very respectfully,

Your obedient servant,

CHARLES F. FOLSOM, M. D.,

Secretary of the State Board of Health.

GENERAL REPORT OF THE BOARD.

*To the Honorable the Senate and the House of Representatives of
Massachusetts.*

The State Board of Health herewith present its Seventh Annual Report:—

THE LAW CONCERNING SLAUGHTER-HOUSES AND NOXIOUS AND OFFENSIVE TRADES.

No formal petitions have been made to the Board under this law during the past year, except with reference to cases which had already been under consideration; namely, the slaughter-houses in Brighton.

In the case of *Talbot et al. v. Corthell, of South Scituate*, judgment had been deferred in 1874. The petitioners are satisfied that the slaughter-house of Mr. Corthell can be managed so as not to be a source of nuisance, and that it has been so managed during the past year. The Board, therefore, voted that no farther proceedings were necessary, and that the petitioners have "leave to withdraw."

In regard to the case of Messrs. John P. Squire & Co., the Board regret that it has not been possible sooner to arrive at a satisfactory decision; but it has been impracticable to do so, owing to the difficulty of eliminating the many sources of possible error in forming judgment.*

The Board have satisfied themselves of the following facts:

I. The last of the basins serving as deposits for filth in the vicinity of the hog-slaughtering establishments in the

* See Sixth Report, pp. 8 to 13.

Miller's River district have been filled, thereby abating one of the most obvious sources of vile odors.

II. All of the three hog-slaughtering establishments—namely, those of John P. Squire & Co., Charles H. North & Co., and the Boynton Packing Company—have been for more than a year past carrying on the various processes of slaughtering and rendering in a satisfactory manner; and, as they are all provided with suitable apparatus for the work, they only need proper care to prevent their becoming sources of nuisance in the future.

III. Six establishments, five of which render house grease more or less decomposed, still conduct their business without proper apparatus to destroy the foul gases.

IV. The complaints, however, have been few in the immediate neighborhood during the past summer.

V. There are still times, generally in the night, and not oftener than once or twice a week, when the characteristic smell of rendering animal matter can be perceived at some distance from the Miller's River district; and it can be traced directly to some of the establishments which are still conducted in an improper manner.

VI. The mouth of the large sewer recently built to carry off the filth of this district has become a source of serious annoyance at low tide, near Craigie's Bridge; so that much of the nuisance has been really transferred from one point to another, although very much lessened in degree.

The Board being of the opinion that the processes, as carried on by Messrs. John P. Squire & Co., are conducted in such manners as to be sources of neither serious annoyance nor of injury to health, have given to the petitioners "leave to withdraw" in the case of *Tyler et al. v. Squire et al.*

The satisfactory condition of these large establishments is probably in a measure due to the fact that the reservation of

their opinion by the Board, and their frequent inspections, have served as an incentive to perfect all the different methods and machinery, and to keep the standard of care and watchfulness in the management up to the highest point.

Even with perfect appliances, such business cannot be properly carried on without the most scrupulous watchfulness and constant attention to all details of the work.

We therefore respectfully recommend that there be some provision made by law for the inspection of such works hereafter.

The petitioners originally complained of nine establishments in the Miller's River district as being sources of nuisance; but they have withdrawn from farther prosecution of the cases. There is nothing more, therefore, that can be done under the law by this Board, unless there be other complaints and another petition sent to them.

THE ABATTOIR AND THE SLAUGHTER-HOUSES IN BRIGHTON.

The report of Mr. J. F. Taylor, President of the Butchers' Slaughtering and Melting Association, gives the statistics of their operations for the past year. The business has been conducted in a manner satisfactory to the Board.

Mr. Taylor says: "It gives me much pleasure to be able to report some increase in business at the abattoir for the year ending December 31, 1875. There have been slaughtered at this place, during the year, 66,541 cattle, 322,705 sheep, and 9,869 calves.

"The business has been done with the usual harmony by all connected with it. I think we may safely say, that no one can be found willing to exchange the convenient and comfortable quarters at the abattoir for the inconvenient, dilapidated places left behind. There is now no slaughtering done in this ward outside of the abattoir, except occasionally of calves. No new buildings of importance have been erected since the last report; those commenced have been finished, and all are now occupied. We have capacity for dressing all meats needed to supply Boston market and vicinity, but not enough separate rooms to allow each one the privilege of conducting his business by himself, which is very desirable. The addi-

tion of one double slaughter-house would obviate all the difficulty for some time.

"The offal is taken to the rendering-house every night, and put into tanks, where it is converted into a 'fertilizer' and other products (with some important and satisfactory improvements), as heretofore. All articles produced are considered to be of the best quality, and find a ready market at good prices. The larger part of the tallow is rendered here with good success, and finds a ready market. The tripe business is also now carried on here.

"We feel that we can say, beyond a doubt, that the Brighton abattoir is a success. From a sanitary point of view, also it has proved so, for in not a single instance have I heard a complaint arising from this business."

In May, 1875, the Board received a petition from N. H. Colman and five others, representing that the following-named parties in Brighton—Gunzenheizer Brothers, Charles W. Sanderson, Henry Zoller, William Weitz, George W. Hollis, Walter L. Wilkins, Dennis Kelly and George Bowman—were carrying on the business of slaughtering within the limits of the city of Boston, in the Brighton district, in improperly constructed slaughter-houses, and in a manner "injurious to the health, offensive, and so as to be a nuisance to the public."

By the evidence presented at the hearing, and by repeated personal examinations of the premises, the Board decided that the public health, and the public comfort and convenience, demanded that these slaughter-houses should be closed. Messrs. Sanderson and Hollis agreed to make arrangements to slaughter in the future at the abattoir. The counsel for the complainants withdrew the case of William Weitz. The rest, five in number, were ordered to "cease and desist" on and after July 1, 1875.

Mr. Zoller refused to obey the order of the Board, and an injunction was served upon him by the supreme court, August 6, which he also neglected to heed. He was therefore brought before the said court, August 24, for contempt. He maintained that he had sold out his business to his brother; that his wife, who owned the premises, had leased them to said brother, and that he therefore had not been carrying on the business since July 1.

The court held that Mr. Zoller's action had been simply one by which he had hoped to evade the law, although he did not intend contempt. He was obliged, consequently, to discontinue the business.

He and Mr. Wilkins afterwards began business anew in some of the abandoned slaughter-houses. Mr. Wilkins was ordered, thereupon, by the City Board of Health, to cease and desist, when he began again in still a third place. On the 27th of October the State and City Boards of Health visited together the slaughter-houses of Messrs. Weitz, Zoller and Wilkins, which were unanimously agreed to be nuisances, such as ought to be abated. October 29th the City Board of Health sent to the three above-named parties notifications that on the third day of November following they (the Board of Health) should issue an order of notice forbidding their continuance of the slaughtering business in the premises then occupied by them. Messrs. Wilkins and Zoller still tried to evade the law by using other old and abandoned slaughter-houses, whereupon the following order was passed and published in the daily papers :—

OFFICE OF THE BOARD OF HEALTH, }
BOSTON, NOV. 8, 1875. }

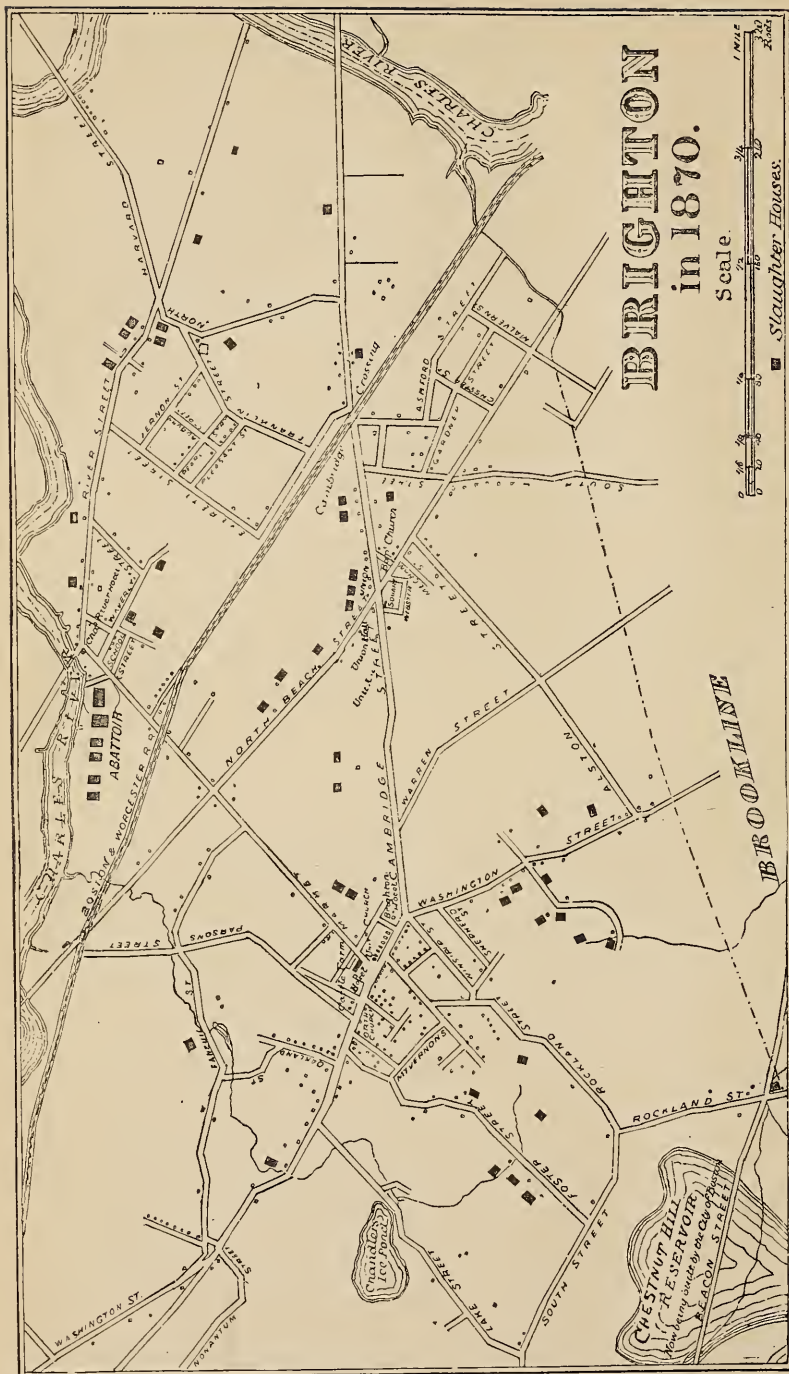
NOTICE TO SLAUGHTERERS AND RENDERERS.

By virtue of the authority given by chapter 26 of the General Statutes, the Board of Health of the city of Boston, makes the following regulation: that on and after November 30, 1875, the trade or employment of slaughtering cattle, calves, sheep or swine, or of rendering tallow or other refuse animal matter, shall not be carried on within the limits of the city of Boston, except on the islands of the harbor, or at the abattoir in the Brighton district, or at such other place, or places, as may hereafter be assigned by the Board of Health.

Attest: WILLIAM L. HICKS, *Clerk, pro tem.*

Messrs. Weitz, Zoller and Wilkins appealed to the superior court from the above Order. The case has not yet been tried, and, during the pendency of the appeal, the business of slaughtering cannot be carried on contrary to the Order. Messrs. Weitz and Wilkins are now slaughtering at the abattoir, and Mr. Zoller in Somerville.

The work of the Board is therefore accomplished, so far as relief from the great nuisances formerly existing in Brighton



NOTE.—The position of the Abattoir, built since 1870, is also given.

and vicinity is concerned. Since the law under which we acted was originally passed, Brighton has become a part of Boston, and the city has appointed a thoroughly efficient Board of Health, with fuller and more summary power than is possessed by the State Board. They have also, what we have not, the facilities for frequent inspection; and all establishments in Boston, of similar character with the abattoir, are under their charge.

We therefore respectfully request that we be relieved of farther care in this matter, and that the power, at present, possessed by this Board to supervise the construction of buildings and apparatus, and the methods of conducting business in the abattoir at Brighton, be transferred to the City Board of Health. Such a change will conduce to the more efficient execution of the spirit of the law.

In the year 1870 Brighton was dotted with offensive slaughter-houses, as will be seen by the accompanying map. They were described in *the First Report of the State Board of Health*, page 23, in the following language: "The floors of the slaughter-houses are of wood, and are saturated with blood. In most of them there is no sewerage; generally an imperfect drain leads to some marsh or low piece of ground, sometimes to a brook. The surrounding ground is filled with decomposing matter."

In a report on the sanitary condition of Brighton, in 1866, the following words are used: "Any description of the slaughter-houses must fall far short of the perfectly disgusting reality, which can only be appreciated by a personal inspection."

The last three of these great nuisances have recently been closed by order of the City Board of Health. It is a source of great gratification to the Board to be able thus to report, that by means of the efficient aid given by the legislature, and with the coöperation of the City Board of Health, they have been enabled to render a whole town a salubrious and agreeable place of residence; while, at the same time, it has within its limits, though somewhat remote from the residences, an admirably conducted abattoir, which never need be a source of offense, and which is capable of supplying with meat all the inhabitants of the metropolitan district.

The special investigations, made during the year, have been upon the following subjects :—

A SPECIAL REPORT, MADE UNDER THE PROVISIONS OF THE
FOLLOWING ACT.*

AN ACT to provide for an investigation of the Question of the Use of Running Streams as Common Sewers in its relation to the Public Health.

Be it enacted, etc.

SECT. 1. The state board of health shall investigate by themselves or by agents employed by them, the subject of the correct method of drainage and sewerage of the cities and towns of the Commonwealth, especially with regard to the pollution of rivers, estuaries and ponds by such drainage or sewerage, and to devise and report a system or method by which said cities or towns may be properly drained, and said rivers, estuaries and ponds may be protected against pollution, so far as possible, all with the view to the preservation of the health of the inhabitants of this Commonwealth, and the securing to the several cities and towns thereof a proper system of drainage and sewerage, without injury to the rights and health of others; also, to report how far said sewage may be utilized and disposed of.

SECT. 2. Said state board of health, or agents employed by them, may enter upon and make surveys of lands, so far as may be required, and without unnecessary injury thereto, and said board may employ such assistants, with the consent of the governor, as from time to time may be expedient. They shall report to the next general court, not later than the first day of February, eighteen hundred and seventy-six.

SECT. 3. The compensation of the members of said state board of health or agents employed by them for services under this act, shall be fixed by the governor and council, which, with the expenses incurred by them, to be approved by the same authority, shall be paid by the treasurer of the Commonwealth on the warrant of the governor.

SECT. 4. This act shall take effect upon its passage.

The investigations under this Act have been divided into three heads, with a summary and recommendations by the Board.

(a.) James P. Kirkwood, C. E., of Brooklyn, was appointed by the Board to make a systematic examination of certain of the river-basins of the State. He appointed as his assistants, E. K. Clark, C. E., L. B. Ward, C. E., and F. L. Fuller, C. E. He has prepared full maps, which cannot fail to be of interest and value now and in the future. The map of the water-sheds of the state, too, it is thought, will long be used for reference.

* Acts and Resolves passed by the General Court of Massachusetts in the year 1875, Chap. 192.

Mr. Kirkwood has brought to the work a rare experience and a thorough knowledge of sanitary engineering. His conclusions and suggestions are fully concurred in by the Board.

In the five basins,—namely, the Blackstone, the Charles, the Neponset, the Chicopee and the Taunton,—only one place is found where legislative action is demanded at present. The Blackstone River is seriously polluted, and some remedy is called for. To meet the requirements of this case, Mr. Kirkwood considers the method of irrigation the most feasible, at least so far as the summer months are concerned. He advises, however, very wisely, that the details of the method be determined by experience. "Beginning with what can be done, the difficulties which these exceptions present will gradually solve themselves, and it would be needless now to speculate upon the precise way in which this will be accomplished."

With regard to systems of sewerage, Mr. Kirkwood says: "To devise a system which, within the compass of a report of this kind, would be applicable in all its details to all cities and towns, would be impossible; every city or town must be the subject of a separate study by a competent engineer, founded on a correct and minute survey of the streets or ground to be drained or sewered, with correct levelling of the whole." The writer, however, gives a few of the important principles to be followed, stating that sewage should always leave a city within twelve hours, at most, after its generation, and that it should never be retained long enough to become putrid.

Mr. Kirkwood's report is followed by an appendix by Prof. W. Ripley Nichols, on the examination of river-water, and the significance of the facts revealed by chemical analysis. He gives five series of tables, embracing a very large number of determinations of the waters of the five valleys which were examined during the past summer. These analyses, made with great care and accuracy, show that the condition of the five rivers is not yet very bad, and that an immediate remedy is called for only in the Blackstone below Worcester.

(b.) Dr. F. Winsor, of Winchester, has examined the question in its sanitary bearings, with the view of ascertaining the actual amount of evil now existing in the State arising from our present method of disposing of our filth. It will be

seen from his report that forty-eight cities and towns have introduced water-supplies for a greater or smaller proportion of their population, while less than half of these same places have any sewers whatever, even the most imperfect. Comparatively little sewage, therefore, gets into our streams.

The greatest evil at present, as shown by him, is undoubtedly the damp and polluted condition of the soil, arising from want of drainage and sewerage. From this cause come too often vitiated water and contaminated air. In small towns and villages, and in isolated houses, slop-water is a fruitful source of mischief and annoyance. When thrown upon the ground day after day, where there is little or no vegetation to purify it, conditions are produced favorable to the development of disease. Neglected privies only add to the danger.

In such cases, the best methods are too costly for general adoption. The writer shows the importance of absolute cleanliness in all these matters, and points out the most practicable methods of attaining it.

The necessity of legislative action is clearly indicated in regard to some of the cities and towns, which will be mentioned in detail in the summary by the Board.

(c.) The Board requested their Secretary to visit Europe, in order personally to examine the methods pursued by various cities in regard to their disposal of sewage. He has given a brief statement of the history of the disposal of filth in European countries, and the steps by which they have arrived at their present positions with regard to the matter.

It will be seen that the water-carriage system is gaining in favor throughout the civilized world; that with care, it is the most convenient and the least objectionable method, and of the greatest advantage in a sanitary point of view, although there are evils peculiar to it which should be carefully provided for.

Where it is possible to do so, the cheapest, and, on the whole, a satisfactory way of disposing of sewage, is to discharge it where it will be carried off without returning, and be diluted in a large volume of water. If this is not practicable, irrigation with the sewage in a fresh state is the most satisfactory solution of the question, at least so far as we may judge from experience in England, France and Germany. Sewage farms

are not prejudicial to health, if properly managed, and a serious pecuniary loss probably need not be incurred from them. When experience has pointed out the best method of carrying them on, it is fair to expect that the process may be attended with profit.

(d.) The summary by the Board contains suggestions as to the best practical methods known to them of meeting the question as it now stands. Their conclusions and recommendations are signed, also, by Mr. Kirkwood, Dr. Winsor and Prof. Nichols.

Cities and towns are mentioned where some action is called for. The Board, however, do not advise any general coercive legislation to cover the whole ground at present.

That the sewage of Boston,* Worcester, Cambridge, Somerville, Salem, Lynn, Woburn and Natick should be dealt with in a manner different from the present, is evident. In other and smaller places, there are also difficulties to be met.

The laws, as now on the statute-book, do not really provide effectual relief for such cases.

In Worcester and Woburn, irrigation would probably be practicable. In the other cities mentioned, different remedies must be applied. Intercepting sewers would meet the requirements of most cases.

In the discharge of the sewage of Natick into Pegan Brook, and finally into Lake Cochituate, there is an ever-threatening danger to the inhabitants of the only large city in our State.

The principle may be broadly stated that *where filth is made, there it should be disposed of*. Every city and every town should be required by law to prevent their filth from annoying their neighbors, or endangering their health.

In order to carry out proper systems of water-supply, sewerage and drainage, each river-basin should be considered as a whole and by itself. In England, different towns lying in one river-basin sometimes unite to form a common system of

* The sewerage of Boston has already been made the subject of a special examination and report, which includes a plan of intercepting sewers capable of disposing of the sewage of the entire metropolitan district, by discharging the same on the ebb-tide at such points that it will be carried out to deep water. See Dr. Winsor's Report, which follows; also City Document No. 3, Boston, 1876.

sewerage, and share the expense of disposing of their filth. Great benefit has arisen in that country, too, from the large powers given to the Local Government Board and to sanitary authorities under recent acts. The appointment of a consulting engineer of eminence, too, has been of the greatest value to cities and towns desiring to get authoritative approval of plans for water-supplies and sewerage.

It is the opinion of the Board that the water-courses in this State can be saved from serious pollution best by placing in some central authority advisory power, upon whose recommendations legislative action should be based to meet each particular case.

In this connection, we would respectfully suggest for the consideration of the legislature the appointment as state engineer of some gentleman of skill and experience, to be paid by the parties who consult him.

There should be absolute prohibition in all cases against casting sewage or filth of any kind into any stream or pond used as a source of water-supply. Where such conditions now exist, the sewage or filth should be diverted to some other channel. For, until our knowledge has so far advanced as to enable us to recognize "germs" of disease, and to destroy them effectually by some simple and easy process, even purified sewage must always be looked upon as a dangerous addition to drinking-water.

The following are the recommendations which the Board respectfully offer in their summary:—

1. That no city or town shall be allowed to discharge sewage into any water-course or pond without first purifying it according to the best process at present known, and which consists in irrigation; provided that this regulation do not apply to the discharge from sewers already built, unless water-supplies be thereby polluted; and provided also that such intended discharge can be shown to be at such point or points that no nuisance will arise from it.

2. That no sewage of any kind, whether purified or not, be allowed to enter any pond or stream used for domestic purposes.

3. That each water-basin should be regarded by itself in the preparation of all plans of sewerage and water-supply.

4. That accurate topographical surveys be always made of all towns before introducing water-supplies or sewers.

5. That steps should be taken, by special legislation based upon investigations and recommendations of experts, to meet cases of serious annoyance arising from defective arrangements for the disposal of sewage.

6. That irrigation be adopted, at first experimentally, in those places where some process of purification of sewage is necessary; and that cities and towns be authorized by law to take such lands as may be necessary for that purpose.

7. That every town or city of over four thousand inhabitants be required by law to appoint a board of health, the members of which shall not be allowed to hold any other offices in the government of their city or town.

Finally, the Board feel that, in the present state of our knowledge, sweeping laws for the general and immediate purification of all our streams would be hardly justifiable, and that they are not called for by the present condition of our rivers.

They hope to continue their investigations during the present year, for which no special appropriation will be required.

SANITARY HINTS.

By HENRY I. BOWDITCH, M. D., Chairman of the Board.

The writer contributes several interesting lessons from his own experience, with the remark which the Board desire to emphasize "that it is expedient to keep practical questions of sanitary law and work constantly before the people." The importance, and even the necessity, of better attention to hygienic requirements, if we would have health, are brought forward in this paper, and we hope that the suggestions offered will receive careful consideration from the community.

DEFECTS IN HOUSE DRAINAGE, AND THEIR REMEDIES.

By EDWARD S. PHILBRICK, C. E., of Brookline.

The large experience of the writer in the construction and arrangement of dwellings has enabled him to give practical results in regard to matters which are too much neglected in many of our houses. It is an interesting fact that the investigations carried on during the past year by so many observ-

ers, acting independently of each other, have led them to the same conclusion; namely, that for our climate and our people, at least, there is absolutely nothing which can take the place of well-ordered water-closets. The writer places before us many instances of almost criminal carelessness in the construction of houses, and shows the importance of licensing plumbers and builders, and the necessity of having their work inspected by some competent officer before it shall be covered up or allowed to be used.

REPORT OF AN OUTBREAK OF INTESTINAL DISORDER ATTRIBUTABLE TO THE CONTAMINATION OF DRINKING-WATER BY IMPURE ICE.

By ARTHUR H. NICHOLS, M. D., of Boston.

The careful analysis by which all other sources of disease are excluded in this case, and the rarity, if not the unique character, of the outbreak, render this paper a valuable contribution to sanitary literature. Impure ice has already been suspected of at least serving to aggravate disease; it is thought that this is the first direct proof that serious illness has been caused by it.

THE REGISTRATION OF PREVALENT DISEASES.

By FRANK W. DRAPER, M. D., of Boston.

This paper embodies a summary of weekly tabulations of prevalent diseases, reports of which were collected throughout the year by the writer under the authority of the Board. The experiment has been carried out ably and faithfully, and has been of great interest and value. It has not been possible to reach statistical accuracy, nor is that to be expected until physicians generally can be induced to record faithfully and truly all their cases, sending their reports to some central office for condensation.

The results which have been obtained by the writer lead us to hope that a complete system of registration may finally grow out of his work. During the past year, weekly reports have been received from nearly one-third of the cities and towns in the State. The knowledge of the appearance of epidemics which even this imperfect registration has given us has been very interesting and suggestive. It is hoped that a

larger corps of observers may be enlisted in the work, and that the Board will be able to carry on and extend a system from which admirable results may be expected. To do this thoroughly, we shall need an enlarged annual appropriation; but the importance to the community of having the knowledge which would be got in this way, will fully repay the small sum which will be required. Registration of disease to supplement the incomplete information got from death-rates, is deemed of vast importance in all countries, and this paper is the first practical contribution to the subject.

We desire to express our cordial thanks to the physicians throughout the State, to whose hearty coöperation in the work we are so much indebted.

THE MORTALITY OF BOSTON IN 1875.

By EDWARD H. BRADFORD, M. D., of Boston.

Dr. Bradford has used the same divisions in the city which were made by the late Dr. Derby, five years ago. The statistics this year are not so complete in the regard to the mortality among children as those given in 1870. The density of the population, an important element in the causation of disease, is given by the writer; and he has carefully pointed out those parts of our city in which the mortality has been excessive. Some suggestions are given, too, as to probable causes, of which bad drainage is one of the most potent.

In many cases, the results obtained this year are the same as were shown by Dr. Draper's tables in 1870. The low, incompletely drained parts of the city will be seen to have the highest mortality, other things being equal, from the preventable diseases.

It is very desirable that similar investigations should be carried out by local boards throughout the State, inasmuch as they furnish the most valuable bases for locating and determining the causes of disease.

THE SURFACE DRAINAGE OF THE METROPOLITAN DISTRICT.

By CHARLES W. FOLSOM, C. E., of Cambridge.

The writer has given a brief sketch of the most important of the low-lying districts in and near Boston, which are also

shown in some detail in the accompanying map. Probably one of the most powerful factors influencing the health of the community throughout the State, extreme poverty excepted, is the condition of the soil upon which their houses stand. The subject is a suggestive one, and merits thoughtful consideration.

HEALTH OF TOWNS.

We desire to express our thanks to our correspondents in different parts of the State for the very full and valuable information which they have sent to us with regard to the prevalence of disease during the past year.

In the majority of the cities and towns, there are no permanent boards of health, the selectmen or a committee of the local government usually serving as such. Many of our correspondents point out the evil of this condition of things in incomplete and inaccurate registration of causes of death, in insufficient attention to measures tending to the prevention of disease, and in general neglect of the vital questions of sewerage and drainage. They have attributed a large amount of preventable disease to causes which admit of being readily removed, and especially to want of attention to the speedy and complete removal of filth.

Many facts and suggestions are given as to the predisposing causes of diphtheria, its prevalence, etc. In our State, at least, this disease, as well as typhoid fever, is very often found associated with bad drainage, and has thus far been of greatest severity in rural districts where there are no sewers and no proper draining of the soil.

We thank the registrars of the cities for their politeness in furnishing the statistics which have enabled us to prepare our weekly reports of mortality.

During the months of July, August and September, Dr. W. L. Richardson filled the office of Secretary *pro tempore*. Upon his retirement, the following vote was unanimously passed :—

Resolved, That the thanks of the Board be presented to Dr. W. L. Richardson for his faithful, able and efficient discharge of the duties of the office of Secretary *pro tempore* during the absence of the Secretary.

At the last session of the legislature, the sum of \$500 was appropriated for the purchase of books, maps, journals, etc., for the library of the Board. It has been our aim to procure only such material as cannot readily be found in other libraries, and it has not been necessary to use any of the money appropriated for this special purpose.

As the metric system of measures is used in parts of the Report, and is likely to come into general use at no very distant day, a table of equivalent values is given.

All of which is respectfully submitted.

HENRY I. BOWDITCH.
RICHARD FROTHINGHAM.
JOHN C. HOADLEY.
DAVID L. WEBSTER.
THOMAS B. NEWHALL.
ROBERT T. DAVIS.
CHARLES F. FOLSOM.

THE METRIC SYSTEM.*

WEIGHT.

1 kilogram	= 1,000	grams.	[2.6795 pounds Troy.]
1 hectogram	= 100	grams.	[3.2154 ounces.]
1 decagram	= 10	grams.	[0.3215 ounce.]
1 gram	= 1	gram.	[15.4339 grains.]
1 decigram	= 0.1	gram.	
1 centigram	= 0.01	gram.	
1 milligram	= 0.001	gram.	

1 kilogram is equal to a weight represented by one liter of distilled water, at 4° C.†

LENGTH.

1 kilometer	= 1,000	meters.	[0.6214 mile.]
1 hectometer	= 100	meters.	[19.8830 rods.]
1 decameter	= 10	meters.	[32.8070 feet.]
1 meter	= 1	meter.	[3.2807 feet.]
1 decimeter	= 0.1	meter.	[3.9368 inches.]
1 centimeter	= 0.01	meter.	
1 millimeter	= 0.001	meter.	

CAPACITY.

1 cubic meter	= 1,000	liters.	[35.3104 cubic feet.]
1 cubic decimeter	= 1	liter.	[61.016 cubic inches.]
1 cubic centimeter	= 0.001	liter.	[0.06102 cubic inch.]
1 liter	= 1.761 imperial pints	= 2.113 pints,	wine measure.

The stère, the unit of solid measure, contains one hectoliter [264.17 gals., or 1.308 cubic yards].

The are, the unit of surface, contains a hundred square meters [119.6 square yards].

1 inch	= 2.5	centimeters (nearly).
1 foot	= 3.048	decimeters.
1 quart, wine measure,	= 0.946	liter.
1 pound Troy	= 0.373	kilogram.
1 ounce Troy	= 31.104	grams.
1 acre	= 0.4046	hectare.

* Many of the names in the French system (like our "dime") are not in practical use; *e. g.*, hectometer, decagram, etc.

† In the centigrade scale 0 (32° + F.) is the freezing-point; 100° + (212° + F.) is the boiling-point. Five degrees C. correspond to nine degrees F.

EXPENSES OF THE BOARD.

REGULAR APPROPRIATION.

Books, ...	\$390 04
Binding, ...	81 45
Maps, ...	36 00
Photographs of Hospitals, ...	9 50
Office Furniture, ...	40 50
Messenger, ...	31 95
Carriage-hire, ...	103 50
Travelling Expenses, ...	109 81
Clerical Services (T. H. Hay), ...	153 00
" " on Consumption in Massachusetts, ...	461 72
" " Indexing Report, ...	22 00
" " on Infant Mortality, ...	136 70
Postage and Stationery, ...	1,074 47
Printing and Stationery, ...	294 37
Drawings of Maps, Plans, etc.	40 50
Pole-axe and Schlacht-Maske for Abattoir, ...	27 45
Express, ...	129 86
Telegrams, ...	4 94
E. Dewson, drawing Plans of Abattoir, ...	75 00
A. C. Martin, " " " (1873), ...	125 00
Lucien Prince, Services on Sixth Report, ...	133 99
Professor W. R. Nichols, Chemical Analyses, ...	129 40
F. W. Draper, Registration of Diseases and Report, ...	266 03
For Special Investigations and Reports (E. H. Bradford, E. G. Cutler, C. W. Folsom, G. T. Hough, E. R. Howe, A. H. Johnson, F. Nickerson, A. H. Nichols, F. E. Oliver, E. S. Philbrick, W. L. Richardson), ...	1,020 00
Miscellaneous, ...	4 40
	\$4,901 58
Deduct for sale of shelves, ...	16 69
	\$4,884 89

SPECIAL APPROPRIATION.

Investigations and Report (including travelling expenses), Jas.

P. Kirkwood and Assistants, ...	\$4,971 44
W. Ripley Nichols, Chemical Analyses, ...	1,095 00
Expenses of Secretary in Europe, ...	843 43
W. L. Richardson, Secretary <i>pro tem.</i> , ...	500 00
C. W. Folsom, Surveys and Report, ...	106 00
F. Winsor, Report and Expenses, }	492 50
W. R. Nichols, Analyses of Water, }	257 50
Express, ...	49 60
Drawings of Maps and Plans, ...	100 00
Travelling Expenses of the Secretary, ...	29 90
Clerical Services, ...	35 00
	\$8,480 37

A SPECIAL REPORT

ON

- I. THE POLLUTION OF RIVERS; AN EXAMINATION OF THE WATER-BASINS OF THE BLACKSTONE, CHARLES, TAUNTON, NEPONSET, AND CHICOPEE RIVERS; WITH GENERAL OBSERVATIONS ON WATER-SUPPLIES AND SEWERAGE. By JAMES P. KIRKWOOD, C. E., of Brooklyn, N. Y.

WITH AN APPENDIX, GIVING

CHEMICAL ANALYSES. By W. RIPLEY NICHOLS, Professor of General Chemistry in the Massachusetts Institute of Technology, Boston.

- II. THE WATER-SUPPLY, DRAINAGE AND SEWERAGE OF THE STATE, FROM THE SANITARY POINT OF VIEW. By FREDERICK WINSOR, M. D., of Winchester.

- III. THE DISPOSAL OF SEWAGE. By CHARLES F. FOLSOM, M. D., Secretary of the Board.

- IV. SUMMARY AND RECOMMENDATIONS.
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RIVERS POLLUTION.

To the State Board of Health of Massachusetts.

GENTLEMEN :—The undersigned has the honor to submit the following statement, growing out of the duties which were assigned to him, on the question of the pollution of the rivers of the State.

JAMES P. KIRKWOOD,
Civil Engineer.

BROOKLYN, 14th December, 1875.

PART I. — PRELIMINARY.

The law requiring the special information, and, incidentally, the examinations to be noticed in this Report, reads as follows :—

AN ACT to provide for an investigation of the question of the use of Running Streams as Common Sewers in its relation to the Public Health.

Be it enacted by the Senate and House of Representatives in General Court assembled, and by the authority of the same, as follows :—

SECT. 1. The State Board of Health shall investigate, by themselves or by agents employed by them, the subject of the correct method of drainage and sewerage of the cities and towns of the Commonwealth, especially with regard to the pollution of rivers, estuaries and ponds by such drainage or sewerage ; and to devise and report a system or method by which said cities or towns may be properly drained, and said rivers, estuaries and ponds may be protected against pollution, so far as possible, with the view of the preservation of the health of the inhabitants of this Commonwealth, and the securing to the several cities and towns thereof a proper system of drainage and sewerage without injury to the rights and health of others ; also, to report how far said sewage may be utilized and disposed of.

SECT. 2. Said State Board of Health, or agents employed by them, may enter upon and make surveys of lands, so far as may be required, and without unnecessary injury thereto, and said Board may employ such assistants, with the consent of the governor, as from time to time may be expedient. They shall report to the next general court, not later than the first day of February, eighteen hundred and seventy-six.

SECT. 3. The compensation of the members of said State Board of Health, or agents employed by them, for services under this Act, shall be fixed by the governor and council, which, with the expenses incurred by them, to be approved by the same authority, shall be paid by the treasurer of the Commonwealth, on the warrant of the governor.

SECT. 4. This act shall take effect upon its passage.

The above Order has in view two important means towards the security and improvement of the general health, one of which, sewerage or drainage, has long been pretty well understood, and to some extent acted upon; and the other, the maintenance of the purity of our running streams, has been in the United States as generally neglected.

Throwing together the sentences of the law which refers to sewerage, it requires the Board of Health "to investigate the subject of the correct method of drainage and sewerage of the cities and towns of the Commonwealth," and to devise and report "how far said sewage may be utilized and disposed of."

In regard to the rivers of the Commonwealth, it requires the above investigation to be made "especially with regard to the pollution of rivers, estuaries and ponds by such drainage or sewerage," and to devise a system by which "said rivers, estuaries and ponds may be protected against pollution, so far as possible, all with the view of the preservation of the health of the inhabitants of this Commonwealth, and the securing to the several cities and towns thereof a proper system of drainage and sewerage, without injury to the rights and health of others."

In previous reports of this Board, particularly the fourth and fifth annual reports, the general questions of sewerage of towns and pollution of rivers have been very thoroughly discussed. In reviewing the same questions now, some repetition will be unavoidable; but, remembering what has been

already said, and that the literature of the subject is now large and accessible, we will endeavor to condense what may require to be said again to meet the Act already quoted, and to further the objects which it has in view.

Without attempting to keep the subjects above defined separate, where they may naturally come together, the present condition of our rivers will first be looked at,—how far they are polluted now, and the evils which that pollution entails, whether under ordinary or exceptional circumstances. To this end, as examples of the polluting exposure to which the rivers of the State are subject now, an exposure against which there is practically no defence through the common law, five of the river-valleys of the State have been examined, and an account taken in each case of all the points where sewage or pollutions of any kind enter the river, including necessarily all factories, the refuse fluids of which enter, and to that extent degrade, the waters of the several valleys. The fluid waters flowing from factories of all kinds will be seen to be the chief cause of pollution in the valleys examined, except the Blackstone; the animal sewage, being as yet but rarely concentrated, is not so palpable, but it is greater, probably, in the aggregate than can be made to appear in the statistics.

The sketches of the valleys attached to this Report will show to the eye their extent and general character, with the positions of the objectionable elements referred to. The statistics will be summarized presently; but, although the mere statement of some of them will sufficiently offend the cleanly instincts of most persons, there are others who will reasonably want to know whether the delivery of a certain amount of such polluting fluids or matters into a river-course necessarily renders that water unfit for domestic use, and injurious to health. The facts affecting this view of the case, to whichever side they lean, should be fairly presented.

It may suffice to refer to the Thames and the Lea, at London, as exhibiting both the apparent insensibility of the human stomach to waters exposed to a considerable measure of impurities, as well as its fearful sensitiveness under the use of the same waters (polluted, some would say, but lightly by sewage) during the prevalence of an epidemic.

It cannot be said that all rivers receiving sewage in any degree are unfit for use; for, of the rivers from which water is freely drawn for human use, there are very few that are not exposed to pollutions of one kind and another, even up to their sources. There is no such thing as pure water, even at the sources, nor anywhere except in a laboratory. Pure water, therefore, or good water, in ordinary parlance, is understood by the engineer to mean a palatable, wholesome water, not insipid like rain-water, and not open to the reception of that class of impurities which endanger the individual health. Palatable water will always have some foreign ingredient in it, which is not necessarily unwholesome; when pollution, therefore, is spoken of in connection with rivers, it refers to those kinds of impurities which, when known, should make the water repulsive for human use. That it does not always do so is the effect of custom, which gets men habituated to almost any evil which is ever present, especially when it cannot by an effort of will be promptly remedied. In this case, too, the evil is but rarely present to the senses at the point where the water is used; it is only known by common report.

The Second English Rivers Pollution Commission give the following as "the chief characteristics of unpolluted water: It is tasteless and inodorous, possesses a neutral or faintly alkaline reaction, rarely contains in 100,000 pounds more than one-half pound of carbon and one-tenth pound of nitrogen in the form of organic matter, and is incapable of putrefaction, even when kept for some time in close vessels at a summer temperature."

In our own country, we have the water-supply of Philadelphia to point to, taken from the Delaware and the Schuylkill, both at places where the water has been much exposed to pollution; and we have the water-supply of Cincinnati, taken from the Ohio River at a point very near to the largest and worst sewer of the city. In Philadelphia, at least, the effective pollution is probably greater than on the Thames, because the water is taken from the streams at points nearer to the polluting deliveries than on the Thames; though these deliveries may be much less in volume when compared with the general volumes of the streams which receive them.

On the Schuylkill, the aggregate of polluting fluids entering the river above Philadelphia is represented to be greater than on the Thames above London, comparing equal volumes of their waters.

We are presented with the same anomaly here that occurs when we compare the annual death-rate of London under the exposed waters of the Thames and Lea with the death-rates of other cities that are supplied with water purer in every way.

The latest statistics within our reach give the annual rate of mortality for New York as twenty-nine per thousand of the population, taking the average of the four years 1870, '71, '72, '73. The average of the same four years for Philadelphia gives twenty-three per thousand. But the Croton waters which supply New York are not exposed, except in a very small way, to any of the impurities which so markedly mix with the waters of the Schuylkill and the Delaware.

The populations of these two cities are somewhat different in general character. New York includes more of a foreign and a floating population, and is in some of the wards very densely occupied. A large part of its working population leave the city at night, however, and find cheap homes in New Jersey and Long Island, whereas the working population of Philadelphia remain within the city lines.*

The reports of the Board of Health of New York give the following as the annual death-rates per thousand, for 1871 and

* By the census of 1870, we have the following statistics :—

CITIES.	Total Population.	Per cent. of Foreign Population.	Total area of city in square miles.	Average Population to each square mile.	No. of dwellings.	No. of persons to each dwelling.
New York, ...	942,292	.44	40.6	23,209	64,944	14.72
Philadelphia, . . .	674,024	.27	122.0	5,525	112,266	6.01

The average density of population is considerably less in New York than in London, which has an area of 117 square miles, and had by the last census (1871) a population of 27,793 to the square mile. The average density of population in Liverpool is even twice as great as it is in London. Philadelphia has lately annexed a large area of country which is very sparsely settled.

1872 in the British cities named. I am not able yet to give the returns for 1873 and 1874:—

	1871.	1872.		1871.	1872.
Liverpool, . . .	35.1	27.1	Edinburgh, . . .	26.9	26.5
Leicester, . . .	26.8	26.8	Glasgow, . . .	32.9	28.4
Manchester, . . .	28.6	31.2	Dublin, . . .	26.2	28.9

All of these English cities derive their water from grounds which are free from the polluting influences to which the River Thames is exposed, and yet the death-rate of London is somewhat below that of any of these cities, being 24.7 for 1871, and 21.4 for 1872. This kind of comparison is necessarily imperfect, because in the manufacturing cities the population is more concentrated than in London, and the amount of deprivation and exposure leading to sickness and suffering probably much greater. The sewerage, too, of most of these places is still imperfect as compared with London. Still, under ordinary circumstances, it would seem to be plain that a considerable measure of impurity may flow into river-waters without sensibly affecting the health of the communities living on them and using them, under ordinary circumstances, provided that the water is drawn from points five to ten miles distant from where the poison enters the stream. The London water companies take their waters from the river at Hampton and Kingston; the sewages of Windsor and Eton enter the river some fifteen miles or more above these points; and, although the banks of the stream, particularly in the eddies, are said to show marks of the impurities which it has received above, its presence at Hampton, where the water is taken for the city, cannot be sensibly distinguished, or proven to have communicated to the water any dangerous qualities, under ordinary circumstances. For this condition of things (as now understood), we are indebted to the fact of the volume of sewage being very small compared with the volume of water in the river; the sewage must be so largely diluted as to have become almost an inappreciable quantity. To secure this dilution, it is obvious that, if the river be a quiet, slow-flowing stream, it might take ten to twenty miles to produce the required mixing; but

if fast-running, or pouring over dams and falls of water, a much less distance would have the same effect. If we dilute urine with a sufficient quantity of clean water and mix it thoroughly, no chemist could detect the impurity; nor could it be shown to be dangerous in any sense, however disgusting the knowledge would be that it was there.

A larger measure than this, including trade impurities, probably exists in the Thames water now at the points where it is used; for at this date (1875) we are informed that Oxford, Reading, Abingdon and Windsor still pass their sewage into the river, although they have commenced sewage works which will in time more or less remedy the evil.

It was long thought that sewage was destroyed by running water, but now it is believed by chemists to be all but indestructible there, and to be rendered insensible, as already said, and inert, only by being mixed largely,—thoroughly diluted, in other words, with at least one hundred times its volume of good water. Sewage distributed over land is appropriated like manure by the vegetation which it finds there, but, passed into running water, it finds little or nothing there requiring its aid. In the one case, it is where it is needed; in the other case, where no profitable use can be made of it. In the still, clear water of shallow ponds, vegetation will often be profuse, protecting the water by such large floating leaves as those of the pond-lily from the hot rays of the summer sun; and in the clear pools of sluggish but pure streams, the vegetation along the banks will often be considerable; but in running water there is but little vegetation,—none, it may be said, if the water is turbid or foul. In running water, therefore, such as mostly prevails in the rivers of the State, the sewage flows on with but little absorption from the very few plants it meets.

It is not to be forgotten that the Thames water is very sensibly improved by the process of filtration to which it is subjected before being delivered to the city. This filtration does not merely remove the sediment which may be in suspension, but it removes a large portion of the organic matter (forty-seven per cent., Dr. Frankland says) which finds place in the natural waters of the river. In the comparison made above with other cities, it is to be noted that the waters of

Manchester and Glasgow are not filtered; the waters, however, of Leicester, Liverpool and Dublin are filtered, and a portion of the Edinburgh supply.

In large cities, any measure of uncleanness and impurity will be submitted to by the poor and the helpless; and until those who are better off are roused in their own interest, and for their own protection, to remedy this tendency, the foul taints engendered by the indifference to cleanliness which accompanies extreme poverty, as well as the inaction which belongs to it, will contaminate and render supine the rich; and, as in many European cities, both classes will have under their noses, it might almost be said, a condition of things that could never long be tolerated here.

If we look again to the Thames, the lessons from which are very marked, we are reminded that the very impure water delivered to the city before 1849 was borne with until the cholera appeared, and the fearful exaggeration of its ravages within the city was traced prominently, if it cannot be said entirely, to the character of the water used. How much mischief is done by the measure of sewage-impurities which is drunk now with the waters of the London supply and the Philadelphia and Cincinnati supplies, cannot be known, so slow and insidious may be its effects on the constitution while no epidemic is present to bring the poison into daylight.

To understand fully the risk which follows the contamination by sewage, especially of potable waters, it will be necessary to review the cholera epidemics of 1849 and 1854 in London.

We are not able to make the kind of comparison that would enable us to understand the benefit to the health of a city population consequent on the use of entirely unpolluted water, as contrasted with the effect produced by the use of polluted water on the health of another population similarly situated. Such cases, in all respects similar, do not exist; but, from the water-history of London, the effect of using different measures or degrees of polluted water can clearly be traced. The cholera epidemics of 1849, 1854 and 1866 give very distinct lessons in this respect, and their histories, so far as they are connected with the water-supply, will therefore be briefly traced.

The metropolis of London is supplied with water by eight companies, five of which take their water from the Thames, two from the river Lea, a tributary of the Thames, and one (the Kent) from artesian wells in the chalk.

During the cholera epidemic of 1848-9, all the companies delivered their water to the city without filtration, the Thames companies taking from the Thames on tide-water, which was at that time subject to the entire sewage-impurities of the city, as well as of all places above it on the banks of the Thames, or of the Lea, which found it convenient to pour their sewage into these rivers or their branches. The epidemic of 1848-9 left the conviction—without, it may be said, absolute proof—that its severity was more or less due to the impurity of the water-supply, and a law was passed, in consequence, requiring all the Thames water companies to take their supplies from a point above tide-water and above London, and to have the water sufficiently filtered before delivering it to the city. A certain period of time was given the companies to make this change and to construct the proper filtering works. The cholera visitation of 1853-4 found certain portions of the city supplied with filtered water taken from the Thames above the city and above the influence of the tidal flow, and certain portions still supplied as before; some of the water-companies having managed in the interim to change their point of in-take to a position up the river, beyond the influence of the sewage of the city, having made provision at the same time for the settling and filtering of the water; while others of the companies had not yet effected the required change of location, nor completed the necessary filtering works.

This cholera epidemic of 1853-4 showed very distinctly that in those parts of London where the filtered water taken from above the influence of the sewage of the city was used, the epidemic was very much less malignant than where the more impure water was used, taken from within the influence of the sewage of this great city. The General Board of Health took some pains to gather the statistics illustrative of this fact. Mr. J. Simon, F. R. S., in his report to the board, made in May, 1856, selects the two water companies for comparison which were supplying the same class of

houses, and as near as may be the same kind of population; the pipes of the two companies for a portion of their districts being laid in the same streets, each supplying about the same proportions of the houses in these streets. The one, the Lambeth, was delivering, in 1853-4, good water, speaking comparatively, from the Thames at Ditton; the other, the Southwark & Vauxhall, delivering bad water from the Thames at Battersea, as in 1848.

"Commonly, in attempting such inferences, the inquirer is baffled by difficulties which render exact conclusions impossible; for populations drinking different waters will often be living in different circumstances of wealth, comfort, occupation, cleanliness, soil, climate."

"In reference to the comparison which had to be made, it is especially important to observe that the tenancies of these two great companies were not set on different parts of the South London area, each isolated from the other. On the contrary, the two populations were, so to speak, mutually interfused. Of thirty-one sub-districts into which the large space is divided, only eight were monopolized by a single water company; while of the remaining twenty-three, each was supplied sometimes in equal proportion by one company and the other."

"In the 24,854 houses supplied by the Lambeth Company, comprising a population of about 166,906 persons, there occurred 611 cholera deaths, being at the rate of 37 to every 10,000 living. In the 39,726 houses supplied by the Southwark & Vauxhall Company, comprising a population of about 268,171 persons, there occurred 3,476 deaths, being at the rate of 130 to every 10,000 living."

"The population drinking dirty water accordingly appears to have suffered three and a half times as much mortality as the population drinking other water."

"But this evidence is only a part of the case; it admits of being greatly strengthened by a second group of facts which the statistical tables exhibit. It was thought proper to see how far any discoverable influence of foul water had been constant to both occasions; and this comparison is of singular interest for our purpose, because the Lambeth Company, which in 1854 gave the superior water, was in 1848-9 pur-

veying even a worse supply than that of the Southwark & Vauxhall Company."

"It has already appeared that the tenantry of the Lambeth Company lost by the epidemic of 1853-4 611 persons. By the epidemic of 1848-9, in the same houses (or rather in as many of them as then existed), the deaths were 1,925." "The earlier figures showed that this population suffered in 1853-4 not a third as much as its neighbors; the present figures give the further fact that it suffered also not a third as much as at the time of its unreformed water-supply."

"Since the epidemic of 1853-4, the Southwark & Vauxhall Company, in obedience to the Metropolis Water Act, has abandoned its former very objectionable source of supply, and for the last few months [May, 1856] has been distributing a water nearly or quite identical in quality with that spoken of as furnished by the Lambeth Company."

"It entirely consists with the facts here set forth to maintain that, under the specific influence which determines an epidemic period, fecalized drinking-water and fecalized air equally may breed and convey the poison, and that this, whether in one vehicle or the other, may be expected to prevail most forcibly against the feeble and ill-nourished parts of a population."

It may be added that the evil effects of much-polluted water as compared with water but little polluted, which become so palpable and distinct in a time of epidemic, cannot cease to exist except in degree when no epidemic prevails. According as the river-waters are cleansed from the impurities which now are expected to hide themselves there, the general health of all living things depending on them and using them, whether in the shape of drink or food, must be benefited.

The cholera reappeared in London in 1866, June, July and August, and called attention again to the character of the water-supply by the "explosion," as it was called (from the sudden and fearful increase of deaths), in that district of London supplied from the pipe-mains of the East London Water Company.

This company derived its water from the River Lea, at a point above Tottenham Mills. The water there passes into

large open settling reservoirs. Moving slowly through these, and depositing there the heavier portion of any impurities in suspension, it is carried by an open canal about three miles in length, to the filter-beds below Lea Bridge. After filtration it is carried by a four-foot pipe, two miles in length, to the pumping station at Old Ford, where it is received into two covered reservoirs in communication with the pumping engines there. It is to be noted that there is one large pumping engine at Lea Bridge on the site of the filter-beds. At Old Ford there are four pumping engines.

"Of the total mortality from cholera in this visitation, of 5,548 souls, no less than 3,909 occurred in the East Districts alone." The population in this case will be a better indication of the condition than the relative area. The population of London for 1866 was 3,037,991; the population of the East London Districts was 598,945, leaving 2,439,045 for the rest of the metropolis. "No relative development of like magnitude, suddenness and shortness of duration has occurred in previous outbreaks of cholera in the metropolis." Nor are we able to trace the great excess of deaths to density of population. "In the recent outbreak, as in previous outbreaks, there was no relation between the density of population as expressed by numbers of persons per acre and the intensity of prevalence of the disease."

The following table shows the weekly deaths :—

Cholera of 1866. Weekly Deaths.

WEEK ENDING—		In the East District (598,945 population).	In the rest of London (2,439,046 population).	WEEK ENDING—		In the East District (598,945 population).	In the rest of London (2,439,046 population).
July	7, . . .	9	5	Aug.	25, . . .	198	67
	14, . . .	20	12	Sept.	1, . . .	122	76
	21, . . .	308	38		8, . . .	74	83
	28, . . .	818	86		15, . . .	77	105
Aug.	4, . . .	916	138		22, . . .	56	94
	11, . . .	673	108		29, . . .	55	122
	18, . . .	369	86				

The exaggeration of the death-rate over the ground supplied by the East London Water Company led to the sus-

picion that the water must be in fault. At Old Ford, beside the two covered reservoirs receiving the filtered water from Lea Bridge, there were two uncovered reservoirs full of unfiltered water; that water being likewise decidedly more impure than the water drawn from the Lea at the point of in-take four miles up the river. The water in these uncovered reservoirs was drawn in part directly from the Lea near by, by soakage. "The river at this part of its course, in June and July, 1866, was a cesspool as well as a canal, for it then received the sewage of the large population inhabiting Old Ford, and the greater portion of Bromley and part of Mile-end." One of the covered reservoirs had a connection with the open reservoirs, and when the filtered water was deficient, the unfiltered water could be drawn from the open reservoir to meet the requirements of the pumps. It was ascertained that some water from these open reservoirs had been used, and to this mixture of a water, which, beside being unfiltered was in other respects much less clean, with the ordinary supply, this exaggeration of the cholera in this district was ascribed. The amount of bad water used seems to have been small, and yet the effect was fearful. Mr. Radcliffe believes that the fecal discharges from some cholera-patients emptied into the Lea there, reached and affected the waters of these open reservoirs.

In corroboration of the belief that the water at Old Ford was contaminated in this way, and was the cause of the explosion of disease, the water delivered by the pumping engine at Lea Bridge, drawing its water directly from the filter-beds, did not produce this effect over the ground supplied by this engine.

The mixture of impure water at Old Ford had occurred frequently before with no perceptible effect on the population supplied. It was only on the occasion of an epidemic that the additional impurity made itself understood. Have we not reason to infer again that, as the waters furnished to London become less polluted than they are now, the general salubrity of the place will markedly improve, and the visits of an epidemic become less and less severe?

All that has been said thus far, although at times apparently contradictory, may be epitomized as follows:—

To those who are willing to risk a certain measure of river-pollution, and who would disregard the warnings of epidemics,

the London supply from the rivers Thames and Lea, can be referred to and quoted as being sufficiently safe for all uses, in healthy times, and under careful management and filtration, notwithstanding the pollutions to which these streams are known to be exposed.

To those on the other hand who would not expose the public health to any risk that can be avoided, and who believe that the gradual emancipation now in progress of the rivers Thames and Lea from sewage and other impurities will certainly improve the health-rate of that metropolis, and defend it measurably from those exceptional visitations of sickness, from which we can never expect to be wholly exempt;—to such, it is believed that the same course, as far as practicable, should be pursued with regard to the rivers of Massachusetts, and that pollutions of all kinds should be, as far as possible, prevented hereafter from passing into them, and that the fluid pollutions now flowing into them should be intercepted and deodorized as far and as speedily as may be practicable; so that the waters may be gradually restored, and held, to that amount of cleanliness at least, which will admit of their being used as fair river waters are used in the arts and manufactures, in which fish will live and thrive, and which animals will not refuse, although the restoration might not always be sufficient to make the water safe for domestic use.

It is to be remembered of the rivers that rise within the State, that their waters are small in volume as compared with the Thames River. They have, besides, more fall per mile; present more frequent opportunities for water power; are much more occupied generally by mills for their volumes of water, and will therefore have a denser manufacturing population on their banks. The refuse from the various fluids of factories may be expected speedily to render these rivers (of small volume in summer) unfit for use, and in this respect far below the standard of the Thames water.

Some of the smaller rivers in England, as the "Ribble," and the "Calder," have run this course, are now black from manufacturing pollution, and have been long unfit for any domestic use.

PART II. — STATISTICS, ETC.

We present now in tabular form the general statistics of the river-valleys examined, and have added those of some English rivers, as far as they can be ascertained, for comparison. (See page 38.)

From this table it will be perceived that, except on the Blackstone River, there is but little concentrated sewage. On the other rivers examined this season, a certain amount of sewage reached the rivers from the factory-operatives' and from other houses near the river-banks. On the Blackstone, the sewage of the city of Worcester is added to this factory-sewage. The fluid refuse from the factories, therefore, some of it very poisonous, produced in the processes of cleansing and preparing the manufactured article, whether paper, cotton cloth, woollen cloth, leather or otherwise,—this refuse forms the chief element in the pollution of these streams.

The following brief statement, explanatory of the kinds of chemicals and other materials used in the many processes of the different manufacturing works referred to, will enable the reader to form some idea of the objectionable character of the fluid refuse resulting from them. This statement has been prepared for me by Mr. L. B. Ward, chiefly from English reports, with some references to present differences in our own practice :—

WOOLEN MANUFACTURE.

The cloth-manufacture includes all the processes to which the raw material is subjected, whatever the fabric that is made, whether fine or inferior cloth, flannels, blankets, or carpets. The wool is deprived of its natural grease and foreign matters, and thereafter dyed. It is then supplied with oil or other lubricant, which is washed out of it after it has served its purpose of conferring the necessary softness and flexibility for spinning and weaving; and thereafter it is fulled and felted, scoured and dried. Some of these steps in the manufacture are omitted in some places and for some purposes, and there are various modes of conducting them. (See page 39.)

	MASSACHUSETTS RIVERS.					ENGLISH RIVERS.				
	Chicopee.	Blackstone.	Taunton.	Neponset.	Charles.	Thames.	Lea above Hertford.	Calder.	Ribble.	
Drainage-area of basin, square miles,	718	276	447	116	296	3,676	244	366	644.5	
NAME OF PLACE ON THE RIVER BY WHICH THE GIVEN AREA IS LIMITED.										
	Chicopee Village.	Blackstone.	North Dighton.	Lower Mills.	Watertown.	Hampton.	Hertford.	Mouth.	Preston.	
Dry-weather flow per diem, at the last point, cubic feet,	12,407,040	5,961,600	9,655,200	3,271,104	3,407,616*	52,252,000	4,332,340	6,120,500	13,135,700	
The same in U. S. gallons,	92,804,659	44,592,768	72,220,896	24,467,857	25,488,967*	390,870,000	32,408,640	45,784,400	98,261,600	
Number of mills or polluting factories on the river and its branches,	72	85	59	52	42	360	32	3,178	52	
Number of mills or polluting factories per square mile of basin,	.10	.30	.13	.45	.12	.098	.131	8.683	.0807	
Number of operatives in these factories, per square mile of basin,	11	30	14.3	29	9.3	-	31.4	-	30.9	
Population of the basin within the given area,	1875. 55,015	1875. 80,638	1875. 65,482	1875. 23,413	1875. 71,153	888,088	73,526	432,992	387,839	
Population of the same per square mile,	76.5	292	145.5	201.8	273.8	241.6	301.3	1,183	601.7	
The portion of the population known or supposed to be sewerage into the streams, per square mile of the basin,	20.06	199	27.1	23.7	72.7	71.9	122.3	1,107	355.7	

* The Charles River gives one-third of its water to the Neponset River, through "Mother Brook"; the natural flow, therefore, would be about one-half greater than the figure given.

*Estimates of the Waste Stuff from the Manufacture into Cloth of
Thirty Tons of Wool (67,200 lbs.).*

MATERIALS USED OR EXTRACTED COMPOSING THE REFUSE.	ESTIMATE No. 1.		ESTIMATE No. 2.	
	Tons.	Cwt.	Tons.	Cwt.
Grease, . } removed from raw wool, . {	8	—	10	—
Dirt, . }	4	—	15	—
Urine, ...	14	—	2	—
Oil, in carding, ...	2	—	—	7
Glue, ...	—	10	1	10
Pigs' dung, ...	2	10	—	—
Pigs' blood, ...	2	5	—	—
Urine (second use), ...	25	—	—	—
Soda, ...	1	—	—	15
Common salt, ...	—	—	1	10
Soap, ...	2	10	—	15
Fuller's-earth, ...	2	10	—	8
Dyestuffs, ...	20	—	21	—
Alum, ...	2	—	—	—

A complete list of the several processes which short wool undergoes in the manufacture of fine cloth, includes upwards of forty successive steps between the fleece and finished goods.

The use of water occurs at least ten times throughout this series of operations,—in the first scouring and washing of the wool, in wadding, washing, and dyeing, and again washing in segging ("segging"; *i. e.*, soaking in a lye of soda and urine), fulling and washing the woven piece, and in roll-boiling and a last scouring. In the first washing of the sorted wool, in the washing after dyeing, and in washing the web both before and after fulling, the water leaves the wool-mill charged with grease and oil; united with the soda and ammonia of the various detergent substances, such as urine and pigs' dung, which have been employed; charged, also, with the waste coloring matters it can carry off. From certain of the washing waters, in which the oil and grease, saponified and taken up, are present in sufficient quantities to make the process of recovering the oil remunerative, a certain proportion of the oil purchased by the manufacturer is recovered.

The first process giving rise to pollution is that of washing

the wool. The fibres of wool as they come from the back of the sheep, even though it had been washed before it was shorn, are covered with a brownish greasy matter, the residue left behind on the evaporation of perspiration. As a rule, the finer the wool, the larger the proportion of this residue of perspiration which it contains. Thus, from one-half to nearly two-thirds of merino lamb's-wool consists of this offensive material, whilst ordinary qualities contain only about one-third of their weight. From one-half to one-third of the grease is of a waxy nature, and is left in the wool after the washing and scouring operations.

The raw wool is boiled in probably, on the average, half its weight of urine, beside about one-twentieth of its weight of other detergent substances (soda-ash, phosphate of soda, and salts of ammonia), pigs' dung being sometimes employed instead of, or in combination with, the urine. All of these are afterward carefully washed out of it, and the whole of the filthy scouring liquid, as well as the washings, pass into the stream.

The next process in the manufacture of "superfine black" cloths, as practised in the west of England, is that of woading* the wool, which consists in steeping the previously washed wool for twenty minutes in a liquor prepared by adding four parts of indigo to 1,000 parts of water. The vat of indigo-liquor is used for a year or more without other renewal than the addition to it weekly of five pounds of indigo for each 1,000 pounds of raw wool manufactured.

The woaded wool is next washed in running water, which of course carries off a certain quantity of the coloring matter.

In the second stage of the dyeing process, sixty pounds of dyewoods with fifty pounds of alum and ten pounds of argol (crude bitartrate of potash) are required in the treatment of 400 pounds of the woaded wool. The wool having been taken out of the second dye-vat, the liquor in which it has been steeped is run to waste; the wool is by some dyers now washed, by others it is left unwashed. The vat is then refilled, 260 pounds of logwood, with a proportion of other dyewoods and a certain amount of nitro-muriate of tin in solution being placed in it. After the same weight of wool has been boiled in this

*So called from "woad," a plant formerly used in this process in place of indigo.

liquor for an hour, it is removed and well washed in running water, being then fully dyed. The contents of this vat are also run to waste.

The volume of spent dye-liquor from the manufacture into fine black cloth of 1,000 pounds of raw wool, may be set down at 6,000 U. S. gallons. This waste liquid is the great source of pollution, so far as the appearance of the rivers is concerned.

The washed wool receives, after being dried, about one-eleventh of its own weight of sweet-oil before being carded; and after being spun, the thread is passed through a weak glue before weaving. After weaving, all these matters are taken out of the web by soaking and kneading it in a mixture of urine, pigs' blood, pigs' dung and soda; and, after being washed free from all these detergent substances, it is fullled along with about twelve pounds of soap per piece of cloth, a process which felts the material together, and causes the threads to shorten. Some two or three pounds of fuller's-earth are subsequently used, and this, with all the soap, is then washed out. The subsequent use of water, as in roll-boiling, is not attended with any further drainage of filthy material from the works.

The difference between the estimates of waste stuff, which have been given in the table, is principally in the use in the former of them of so large a quantity of pigs' dung, pigs' blood and urine in the scouring process before fulling. This, however, it is believed, still represents the ordinary practice.

Comparison of the Liquids Wasted from Woollen-Factories.

DESCRIPTION.	IMPURITIES PRESENT IN 100,000 PARTS.			
	Solid matters in solution.	Mineral matters in suspension.	Organic matters in suspension.	Total impurities.
"Wool-suds" in which raw wool has been scoured, ...	1,099.4	870.95	2,611.65	4,582.
Waste liquor from dye-vats, . .	107.6	24.08	77.92	209.6
Washing water from dyed and scoured goods, ...	29.62	.72	.88	31.22

COTTON MANUFACTURE.

The operations carried on in bleaching, dyeing and printing calicoes, involve the pollution of large volumes of water, partly by mineral, but chiefly by organic matters. In most cases the coloring matters, which it is the object of the manufacturer to fix upon the tissues, are contained in but very small proportion in the dyestuffs employed; thus the weight of actual coloring matter in one ton of madder is not more than two and a quarter pounds; hence nearly the whole of these dyestuffs is refuse matter, which, partly in solution, and partly in the solid condition, is carried by the goit* of the mill into the adjacent stream. According to careful experiments made on this point, only twenty-five per cent. of the madder used for dyeing goes into the stream in a state of suspension; the remainder, being rendered soluble in the processes of dyeing and garancine making, consequently enters the stream in solution, hence the large proportion of organic carbon and organic nitrogen in solution in the effluent water.

The following is a list of the chief materials commonly used in works for printing and dyeing calico:—

<i>Dyestuffs, and adjuncts thereto:</i>	<i>Chemicals:</i>
Madder or Garancine (prepared madder).	Sulphuric acid.
Peachwood.	Muriatic acid.
Logwood.	Soda-ash.
Sumach.	Bleaching-powder.
Cows' dung.	Lime.
Starch.	Soap.
British gum.	Arsenate of soda.

With the exception of a small proportion of the mordants, and of the starch used in stiffening the finished goods, all the chemicals find their way into the stream, since they are used in scouring, washing, and cleansing, and are not contained in the goods sent out of the factory. We may gain some idea

* Or go-out; *i. e.*, sluice-way.

of the extent of the pollution arising from the processes in question, by considering the annual consumption of dyestuffs, chemicals, and other materials in one such factory of about average size, employing 250 hands, viz. :—

Quantities of Materials used Annually by the Kinder Printing Company.

DYESTUFFS, ETC.	Pounds.	CHEMICALS.	Pounds.
Madder, . .	560,000	Sulphuric and muriatic acids, . .	280,000
Peachwood, . .	8,512	Soda-ash, ...	112,000
Logwood, . .	58,240	Bleaching-powder, ...	31,360
Sumach, . .	17,696	Lime, ...	67,200
Cows' dung, . .	127,680	Soap, ...	98,560
Starch, . .	109,760	Liquid arsenate of soda, containing	
British Gum, .	42,560	833 pounds metallic arsenic, .	42,560

The quantity of polluted water sent out from these works is estimated at 600,000,000 United States gallons per annum, the refuse matter with which it is charged amounting to 1,446,000 pounds.

The use of arsenate of soda in printing and dyeing calico demands especial notice. It is seldom included in the returns of materials used, but it is well known to the trade that its employment is now almost universal in all descriptions of madder-dyeing.

In order to fix the coloring matter of the madder-root upon calico, it is necessary first to impregnate the latter with a material called a mordant, with which the coloring matter subsequently combines chemically, forming an insoluble compound which cannot be removed from the tissue by washing.

After the application of the mordant to the calico, it is necessary to remove the excess, and also to render the remainder and really useful portion, which has penetrated into the interior of the cotton-fibre, absolutely insoluble in water. Both these objects are effected by an operation technically called "dunging," because formerly the mordanted calico was passed through a hot bath containing an emulsion of cows' dung. It was subsequently found that the dung-bath could be advantageously replaced by a solution of phosphate of soda

containing some phosphate of lime and sulphate of lime in suspension, the requisite material being manufactured and sold under the name of dung-substitute. Finally, about twenty years ago, it was discovered that arsenate of soda increased both the economy and the efficiency of the dung-bath, and a mixture of cows' dung and arsenate of soda appears to have now, to a great extent, superseded the older mixtures in this part of the calico-printing process.

Arsenate of soda is a compound of arsenic acid and soda, containing about thirty-three per cent. of metallic arsenic, and is a virulent poison.

Turkey-red dyeing is a special process for dyeing calico with madder, largely carried on in Scotland. The color fixed by it is celebrated for brilliancy and strength. For the purpose of showing the polluting power of works in which this process is practised, the following table is given of the quantities of the principal materials used in one year, and in bleaching and dyeing 1,080 tons of yarn and cloth, at a factory in which 750 hands are employed.

Materials used in Turkey-red Dyeing.

Garancine, . . . 1,080,000 pounds.	Alum, . . . 678,000 pounds.
Sumach, . . . 540,000 "	Soda, . . . 1,080,000 "
Blood, . . . 1,782,000 "	Soap, . . . 345,600 "
Olive-oil, . . . 678,000 "	Water, . . . 693,600,000 U.S.gals.

One-half of the olive-oil, or its products of oxidation, remains in the goods at the completion of the dyeing process.

The comparison of analytical results in the following table shows that the drainage from Turkey-red works contains a much larger proportion of arsenic than that from dye and print works.

Analyses of Waste Water from Calico Dye and Print-Works.

DESCRIPTION.	IMPURITIES PRESENT IN 100,000 PARTS.							
	DISSOLVED MATTERS.				SUSPENDED MATTERS.			Total Impurities in 100,000 Parts.
	Total Solid Mat- ters.	Organic Carbon.	Organic Nitro- gen.	Metallic Arsenic.	Mineral.	Organic.	Total Suspended Matters.	
Drainage from calico dye and print works. Av'ge of five works. }	50.2	4.226	.299	.034	7.02	18.97	25.99	76.2
Drainage from Turkey- red works, . . . }	66.8	3.471	.510	3.200	27.76	11.12	38.88	105.7

BLEACH-WORKS.

Bleaching operations are usually carried on in calico print-works, but also occasionally in separate factories. The pollution arising from them appears to be of a comparatively slight character, consisting chiefly of alkaline and slightly soapy liquids, solution of chloride of calcium, sulphate of lime in suspension, and traces of chloride of lime in solution; these are copiously diluted with water used in washing the bleached calicoes.

ADDITIONAL AS TO "COTTON-BLEACHING."

A communication from Edward Schunck, F. R. S., bleacher and dyer of cotton yarns and calicoes, given on page 158, vol. 2 of the Report on the Mersey and Ribble Basins, 1870, furnishes the following details relative to the bleaching process.

"It is well known that nothing is added to cotton-fibre previous to or during the process of spinning into yarn, but that on the contrary mechanical impurities, such as fragments of seed vessels, are to a great extent removed. During the process of yarn-bleaching, however, about five per cent. by weight of matter, inherent in the fibre, is removed from the cotton. This matter is for the most part dissolved by the soda-lye with which the yarn is in the first place treated.

The product of this treatment is a dark brown liquid, which is of course allowed to flow into the nearest stream.

The substances removed by this treatment are, principally, pectine, organic coloring matters, and fatty acids. These, when allowed to pass into streams, produce only slight evil effects beyond the brown coloration which they impart to the water, because they are bodies which are only slightly capable of undergoing putrefactive decay. Their alkaline solutions, when allowed to stand exposed to the air, are after some time found to be covered with mold, but never become foul or stinking. The only substance removed from cotton by treatment with alkali which is liable to putrefaction, is a minute and almost inappreciable trace of albuminous matter.

During the succeeding stages of the bleaching process, the yarn is treated with chloride of lime, then with sulphuric acid, several times in succession. These materials, after effecting the purpose for which they are intended, are passed in a state of solution into the streams.

All that has been said regarding the bleaching of cotton yarn applies also to the bleaching of calicoes, with this addition, that the alkaline liquid resulting from the treatment of piece-goods with soda and lime contains a quantity of nitrogenous matter derived from the flour-dressing which is always used in preparing the yarn before weaving."

LINEN AND JUTE MANUFACTURE.

The chief operations in this branch of industry which affect running water are, 1st, the bleaching of linen and jute; and 2d, the dyeing of these fibrous materials.

The process known as flax-steeping, consists simply in placing the flax in a pit filled with water long enough to cause the partial putrefaction of the stem, or of those softer portions of it which hold its fibre and woody part together. This process is conducted on the farms where the flax is grown, and will not be farther noticed here.

Linen and Jute Bleaching.

The operation of bleaching linen differs very widely from the corresponding processes applied to calico; for, whilst the pollutions caused by the latter are, as has been said, of a

comparatively slight character, those of the former constitute one of the most formidable sources of water-nuisance with which we have become acquainted. At every stage of the treatment of flax with water, from the first steeping of the plant to the final finishing of the manufactured goods, linen fibre, unlike that of cotton, appears to yield to water and solutions of various chemicals, again and again, large quantities of soluble organic matters of great polluting power.

The fibre received by the bleacher is first steeped for about a fortnight in tubs of water, at the end of which time the water from the tubs is discharged into the neighboring stream; the fibre is next steeped overnight in a caustic soda-lye, which is run off into the stream early the following morning. The bleaching proper, which is performed chiefly by the use of chlorine, is commenced after the fibre has been spun, and, so far as it relates to the fouling of the streams, is completed before the cloth is woven.

The bleaching process varies somewhat in different establishments, but the following description embodies all its essential features as carried out in the factories in the vicinity of Dundee, in Scotland, where is afforded one of the best illustrations of river-pollution arising from this cause.

One thousand and eighty pounds of linen and jute-yarn, 180 pounds of soda-ash, and 10,000 pounds (1,200 U. S. gallons) of water are put into a capacious caldron and boiled for some hours. The liquor from this first boiling is excessively offensive, and highly polluting, yielding upon analysis 257 pounds of dissolved and twenty-two pounds of suspended matters, exclusive of the weight of the alkali. The yarn is similarly boiled a second time, but with only one-fifth of the above-mentioned quantity of soda-ash. The liquor produced even by the second boiling has a polluting power at least twenty times as great as that of ordinary town-sewage; the impurities in it amounting to forty-three pounds more than the weight of the alkali, the loss of organic substance from the yarn in the two boilings thus being thirty per cent. of its original weight.

After washing in water, the bleaching process is continued by immersing the yarns in a solution of chloride of lime, then in dilute sulphuric acid; the object being to liberate chlorine from the chloride of lime, with the solution of which the

fibres are saturated. From the acid-vats the goods are transferred to a solution of carbonate of soda mixed with soap, for the purpose of neutralizing the sulphuric acid. This series of operations needs to be frequently repeated to obtain the necessary whiteness. The waste, polluting products from all these operations are discharged in an unpurified condition into the stream. They are, 1st, the caustic-soda lye; 2d, waste chloride-of-lime liquor; 3d, waste sulphuric-acid liquor; 4th, waste carbonate of soda and soap-liquor.

Returns from eight of these factories, consuming annually 10,000,000 pounds of mineral chemicals, show that to each 1,000 pounds of yarn there is used on the average, viz. :—

Pounds chloride of lime,	.	.	.	.	.	197
soda-ash, ...	.	.	.	.	.	68
sulphuric acid, ...	.	.	.	.	.	43
Total pounds, ...	.	.	.	.	.	308

Goods weighing in the aggregate 32,500,000 pounds, are annually bleached at these works, yielding an amount of organic impurities estimated at not less than that of the chemicals used (10,000,000 pounds).

Jute-Dyeing.

The polluting liquids arising from the dyeing of linen and jute are essentially the same as those produced in the calico industry.

Before being submitted to the process of dyeing, jute is first carded, rove, and spun, operations in which water is not required; some train-oil is, however, mixed with the fibre, which, on being subsequently washed or scoured out, contributes to the pollution of the general drainage of the works.

If the spun jute is to be dyed of a bright color, it requires to be first bleached in the mode already described; but black and dark colors are imparted to the unbleached material.

The colors chiefly used are those technically known as "spirit colors" among calico-printers; they consist of decoctions of dyewoods to which chloride of tin is added. The hanks of spun jute are immersed in these liquids, and afterwards washed in water.

Blacks are dyed with logwood and copperas, or nitrate of iron; reds with Lima-wood; yellows with turmeric, fustic, or quercitron bark; and browns with catechu, to which some sugar of lead is added. Prussian blue and aniline colors are also to some extent employed as dye-wares.

The sample of mixed liquid of which the analysis is given below, was taken from the general drainage of an extensive manufactory of jute and flax goods, in which the operations of bleaching, printing and dyeing are carried on together; the annual consumption of dye-wares is 350,000 pounds, and of bleaching substances 542,000 pounds. Fifty-five million seven hundred and twelve thousand U. S. gallons of foul water are annually produced from washing, printing, and bleaching, and 26,656,000 gallons from dyeing processes.

Analysis of Waste Water from Jute Dye-Works.

DESCRIPTION.	DISSOLVED MATTERS.				SUSPENDED MATTERS.			Total Impurities in 100,000 Parts.
	Total Dissolved Matters.	Organic Carbon.	Organic Nitrogen.	Chlorine.	Mineral.	Organic.	Total Suspended Matters.	
Drainage from works, .	236.5	9.619	.529	42.8	17.84	35.32	53.16	289.7

SILK-MANUFACTURE.

The polluting liquids discharged from silk-works do not differ essentially from those issuing from calico and woolen works; but the degree of pollution is considerably less in the former, whilst the volume of liquid is comparatively insignificant.

To prepare raw silk for dyeing, the gum which naturally adheres to the fiber is removed by boiling with a solution of soap. The gum constitutes about twenty-five per cent. of the weight of the silk; and about twenty pounds of soap are used for discharging the gum from one hundred pounds of silk. Altogether, about forty pounds of soap are used for each one hundred pounds of silk, and all the suds are habitually thrown into the stream. The dyes used are chiefly those known as aniline colors, and being very expensive, and capable of being

applied to the silk almost without waste, but little goes into the rivers.

One hundred thousand parts of waste water from silk print-works, on analysis, yielded 26.50 parts of "total solid matter in solution."

PAPER-MANUFACTURE.

The manufacture of paper, as usually carried on, consists of two principal processes: the first, that of preparing the pulp; the second, that of spreading this pulp into sheets. The latter of these is a merely mechanical process of rolling, drying, pressing, etc.; it is only in the first part of the manufacture, therefore, that any nuisance or injury to rivers can arise.

The preparation of pulp is an operation partly chemical and partly mechanical, and varies with the nature of the raw materials employed, and the quality of paper to be made. The materials upon which the paper-maker has hitherto principally depended, are cotton and linen rags, either white or colored, old ropes, canvas bags, and cotton waste. More recently the demands of the manufacture have led to the introduction of other descriptions of fiber; in Great Britain, the alpha or esparto, a species of sedge which grows in the wild state in parts of Spain and Northern Africa bordering on the Mediterranean, has been extensively adopted within the past fifteen years; in the United States, the coarser portion of the stalk of the plants which affords the jute-fiber has been found a cheap and serviceable substitute for rags. The other crude fibers employed by the paper-maker which require notice here are obtained: first, from straw which is frequently used, and with considerable advantage, in connection with linen and cotton rags, in the production of printing-paper; and second, from wood of various kinds, the use of this material being, however, limited.

For the manufacture of writing and printing papers, nothing has yet been discovered to greatly lessen the value of rags, which possess, also, the great advantage of having been repeatedly prepared in advance for paper-making by the numerous alkaline washings which they necessarily receive during their period of use.

Whatever the raw material may be, it is necessary to dissolve out of it, by means of alkaline solutions and heat, an amount of organic refuse-matter which would be inadmissible in the pulp. In the crude fibrous substances esparto, straw, jute and wood, the organic matters required to be thus separated from the fiber consist chiefly of vegetable albumen, resin, gum, fatty and coloring substances, and the silica always present in combination with a coating of raw fibers. The process employed, and the refuse-liquor produced, are chemically entirely analogous to the flax-steeping and linen and jute scouring processes and the refuse resulting from them.

The organic matters to be eliminated from ordinary rags, are partly of animal and partly of vegetable origin, and include fatty and glutinous substances, fibers of wool or silk interwoven with those of the cotton or linen, and the coloring materials of the dyer. A certain proportion of these are separated as "rag-dust" in the preliminary operations of "cutting" and "dusting"; the remainder disappears in the treatment with alkali in the form of liquid refuse, with which alone we have to do.

The following table is intended to show the comparative polluting power of the principal articles used for paper-stock, and the proportion of useful product obtainable from each:—

Organic Refuse and Useful Fiber in 100 Parts, Dry Weight, of Paper-Stock.

DESCRIPTION.	Useful Fiber.	Dry Refuse.	Liquid Refuse.
Fine white rags, . . .	85 per cent.	9 per cent.	6 per cent.
Colored cotton rags, . . .	76 "	12 "	12 "
Esparto, . . .	60 "	—	40 "
Jute "butts," . . .	70 "	—	30* "
Wheat straw, . . .	52 "	—	48 "
Oat and rye straw, . . .	47 "	—	53 "
Poplar-wood, seasoned, . .	37 "	—	63 "

* Becomes 50 per cent., if bleached fully.

The first chemical operation to which the raw material is subjected, is that of boiling in an alkaline solution at a high temperature, for the purpose of extracting or destroying the

fatty, glutinous, and coloring substances surrounding the pure fiber which is needed by the paper-maker. There are differences of opinion and practice as to which of the alkalies should be used, as to the quantities required, and as to the best mode of combining their action. The crude organic matters present in straw, esparto, and wood are found to yield most readily to a strong solution of caustic soda, and in Great Britain this alkali is made use of, also, for boiling rags.

The soda-lye is prepared: 1st, from so-called caustic soda-ash, in which from one-fifth to two-fifths of the contained alkali is in the form of hydrated caustic soda; 2d, from soda-crystals, pure hydrated carbonate of soda, containing about twenty-two per cent. of actual soda; or 3d, from soda-ash, the crude carbonate of soda, containing at the standard strength forty-eight per cent. of actual anhydrous soda,—the last being the most generally used.

The caustic solution is obtained by boiling the crude carbonate (soda-ash) with quicklime,—one hundred pounds of soda-ash requiring to be treated with forty-three pounds of pure, freshly-burned lime. In some paper-mills the lime and soda are put into the boiler with the paper-stock, to which water is then added; but the common practice is to prepare the caustic solution in a separate vessel, in which the mixture is allowed to settle, the clear liquor being then used for boiling the paper-stock. When this course is followed, the lime which has been converted into an insoluble carbonate is commonly mixed with water and run to waste, being the first liquid refuse produced.

The caustic soda-solution is not invariably used for cleansing the fiber: in the practice of the American paper-makers, caustic lime is substituted for it in the digestion of ordinary rags. This alkali is believed to be less injurious than soda to the fiber, while it has the property of combining with the various fatty and other substances present in the rags, with which it forms insoluble calcareous soaps. From five to fifteen per cent. of lime is required where it is used by itself. Where colored rags are operated upon, the treatment includes a second boiling, with two per cent. of soda, for the removal of coloring substances which do not yield to lime alone.

When writing or printing paper of good average quality is

to be made from any of the raw materials which have been named, alkalies are required for their preparation nearly as stated in the table inserted below. The proportion of alkali varies, not only with the nature of the materials used as paper-stock, but also with the quality of the manufactured product.

Alkalies used for Digesting 100 pounds of Paper-Stock.

RAW MATERIALS OF PAPER-STOCK.	Soda-ash containing 48 per cent. of soda—pounds.	Caustic lime—pounds.	Total alkalies—pounds.
White rags, ...	3	8	11
Colored rags, ...	2	13	15*
Esparto, ...	17	7	24
Straw or jute, ...	25	15	40
Jute "butts,"	—	25 to 50	25 to 50†
Wood, ...	100	60 to 100	160 to 200

* Lime followed by soda.

† Unbleached product.

Next to the fouling of water by the washing of filthy rags, the discharge into rivers of the soda-liquor in which esparto has been boiled, is the most formidable source of pollution from paper-mills. During the process of digestion, which is usually carried on in large wrought-iron boilers in which a temperature considerably above that of boiling-water is maintained by means of high-pressure steam, the soda combines with the silica and resinous matters to form soapy compounds. The resulting liquid, technically termed "boilings," is of a dark brown color, approaching to black, and is so soapy in its nature that one volume of it added to two thousand volumes of pure water, produces on agitation an extremely persistent lather or froth. The "coolings," as the cold water is termed which, upon the removal of the "boilings," is injected into the boilers for the purpose of cooling and partially washing the fiber, is a diluted form of the same liquor. A river polluted by these waste liquors has been known to carry a froth or scum over its whole surface for long distances, and which has accumulated at some points to a thickness of four or five feet. An analysis of this polluting liquid is given for reference.

Analysis of Waste Esparto Liquor Impurities in 100,000 Parts.

Total solid matters in solution, ...	4,038 00
Organic carbon, ...	939.84
Organic nitrogen, ...	77.04
Ammonia, ...	1.12

When the process of boiling, which in the case of straw or esparto occupies many hours, is concluded, the alkaline liquid is allowed to drain off, and the fiber is transferred to the "engines," to be washed and "pulpd." The fiber is now subjected to the action of running-water, aided by the movement of certain rollers and drums coated with wire gauze. The main object of this operation is to remove the alkali, together with the matters which it holds in solution; but its effects also changes in the mechanical condition of the fiber, which, although very important to the paper-maker, have no special bearing upon the subject under consideration. The time required for washing esparto is from twenty-five to sixty minutes, according to the paper required; the quantity of water employed for each one thousand pounds of the raw material probably averaging five thousand United States gallons. Rags occupy from three to six hours' time, and require a proportionately larger quantity of water.

The liquid from the washing-engines differs from the boilings in having a very much smaller quantity of mineral and organic matters in solution, and consequently being much less frothy, as well as in containing considerable quantities of suspended matters, chiefly useful fiber. The following figures give the average of a number of analyses of waste washing-water, the specimens having been taken at intervals during the process, which, as the water is continually passing in and out of the engine, is one of progressive dilution.

Composition of "Washings" from Paper-Works. Impurities in 100,000 Parts.

Organic matters in suspension, ...	81.25
Mineral matters in suspension, ...	10 50
Organic and saline in solution, ...	95.75
Total, ...	187.50

The waste alkaline liquor from the boiling process, with all matters dissolved by it from the rags, straw, esparto, etc., and the water from the washing-engines, constitute the second liquid refuse from the paper-manufacture, the first being the lime-residuum from the soda "causticising" process already described.

When the washing is completed, the pulp, if intended for white or slightly colored paper, is bleached by means of chloride of lime. The solution of bleach only is employed by paper-makers, and a quantity of solid refuse consisting of lime accompanied by undecomposed bleaching-powder and similar compounds remains in the vats in which the chloride of lime has been treated. This residuum is deleterious to fish, and should on no account be admitted into running waters.

The clear bleach-liquid is brought into contact with the pulp, and left so for some time; the chlorine of the bleach then slowly exhausts itself in the destruction of the coloring matter of the pulp.

The quantity of bleaching-powders (chloride of lime) required for one thousand pounds of paper differs with the nature of the raw material, and varies for each according to circumstances.

RAW MATERIAL OF PAPER-STOCK.	Pounds Chloride of Lime per 1,000 lbs. of Paper.
Linen or cotton rags, ...	35 to 140
Straw, ...	150 to 250
Esparto, ...	200 to 400

Certain chemicals are added to the bleach-liquid after it is brought into contact with the pulp, in order to increase the energy of the bleaching-powders; alum being used by some paper-makers, and sulphuric acid by others, for this purpose. The first of these requires to be used in the largest proportion; its weight amounting sometimes to nearly one-tenth of that of the paper.

After the conclusion of the bleaching process, the liquor from it ought to contain but a very small proportion of chlorine

capable of being set free by the addition of sulphuric acid ; nor should any great excess remain in the pulp to require subsequent washing out.

The spent bleach-liquor constitutes the third liquid refuse from the paper-manufacture.

The pulp has now to undergo further important mechanical treatment, which does not, however, require special notice here ; and after having, in the case of printing-papers, received an addition of "size," composed chiefly of alum, soda, and resin, is finally ready to be dealt with by the machine for the formation into lengths of paper.

The fourth liquid refuse from the paper manufacture consists of the waste waters from the making-machines.

They are considerable in quantity and, as a rule, highly charged with fibrous and saline matters, which sometimes amount to $\frac{1}{350}$ part of their weight ; where printing-paper is made, the "size," which is in solution in these waste waters, usually renders them very frothy.

It will be seen that refuse arises in the manufacture of paper at the following stages :—

1. The dusting process.
2. The lime-refuse from the treatment of soda.
3. The alkaline waste liquors from the boiling process.
4. The insoluble part of the bleaching-powders.
5. The waste bleach-liquor, if used in excess and without due caution.
6. The drainage of the making-machines.

Of these, the first, second, and fourth may be excluded from the drainage without difficulty. Among the other forms of refuse specified, the third is at once a source of injury the most serious and the most troublesome to dispose of. With the exception of the small portion of the liquid which will drain off, no attempt is usually made to deal with this refuse except by the prolonged washing in the engine, which washing employs so large a portion of water that it has been supposed to be practicably impossible to deal with it subsequently, and it has therefore been thrown directly into the river. On

this point it is also to be observed that the alkaline waste liquors from the digestion of fine rags average but about one-tenth of the strength of those yielded by the treatment of esparto or straw.

The amount of polluting refuse arising from the manufacture, as it is carried on in paper-works of the highest class, will be best learned from the actual examples contained in the appended statements of the operations of four establishments situated on the same stream (the North Esk) in Scotland. Certain methods of purification which have been adopted in these and other paper-mills upon the same stream, have had the result, it is stated, of diminishing the pollution due to the discharge into it of liquid matters, 75 per cent., without taking into account matters properly classed with dry refuse.

North Esk Paper-Manufacture (1870).

NAME OF MILL.	Description of Paper Manufactured.	Weight of Paper made in the year—pounds.	Proportion of raw fibrous materials used—per cent.	Weight of solid impurities contained in liquid refuse—pounds.
Polton, . . .	Fine writing-paper,	1,120,000	100.00*	309,120
Esk, . . .	Fine writing-paper,	3,315,000	{ 14.20* 85.80† }	2,763,700
Springfield, . .	Printing-paper, .	2,464,000	{ 9.25* 90.75† }	2,648,300
Dalmore, . . .	Printing-paper, .	1,496,000	{ 1.86* 98.14† }	1,757,200

* Rags.

† Esparto.

DETAILS OF THE NORTH ESK PAPER-MANUFACTURE.

Statement of Materials Actually Used, and Liquid Refuse estimated to result from the Manufacture of 1,000 pounds of Paper, for Various Cases.

NAME OF MILL AND QUALITY OF PAPER MANUFACTURED.	PAPER-STOCK AND ORGANIC REFUSE.			CHEMICALS AND SALINE REFUSE.			
	Gross Weight of Raw Material consumed— pounds.	Calculated Net Weight deducting, viz.: rag dust, 10 per cent.; water fixed in crude fibres, 10 per cent.— pounds.	Loss from Net Weight during Manufacture. Liquid Refuse—p'ts.	ALKALIES.	BLEACHING POWDERS.	ALUM AND ACID.	
				Gross Weight used—pounds.	Calculated Dry Weight of Liq- uid Refuse— pounds.	Gross Weight used—pounds.	Calculated Dry Weight of Liq- uid Refuse— pounds.
POLRON MILL. Manufacture of fine writ- ing-paper, ...	Rags, . 1,316	Rags, . 1,184	184	Caustic soda. 42.	32.76	Estimated. 64.	Al um. 27.2
				Soda-ash. 2.	2.		
ESK MILL. Manufacture of fine print- ing-paper, ...	Rags, . 237 Esparto, 1,433	Rags, . 213 Esparto, 1,290	503	Caustic soda. 273.2 Soda-crystals. 25.	185. 9.5	170.3 85.15	Al um. 29.1 Vitriol. 17.1 Antichlor. 2.85
				Soda-ash. .5	.5	182.	
SPRINGFIELD MILL. Manufacture of printing-paper, ...	Rags, . 182 Esparto, 1,782	Rags, . 163.6 Esparto, 1,604	767.6	Caustic soda. 272.7	212.7	91.	Al um. 2.97
				Caustic soda. 127.2	99.2		
DALMORE MILL. Manufacture of print- ing-paper, ...	Rags, . 36 Esparto, 1,883	Rags, . 32.3 Esparto, 1,695	727.3	Soda-crystals. 226.	85.9	242.5	Al um. 31.
				Li me. 161.7	110.	56.9	

NOTE.—The lime used for "causticising" soda, and the "waste bleach-lime," are excluded from the liquid refuse. The analyses were made for the Rivers Pollution Commission.

NAME OF MILL, AND QUALITY OF PAPER MANUFACTURED.	WATER. Total Quantity Consumed in the Manufacture.	COMPOSITION OF THE DRAINAGE-WATER.				ACTUAL COMPOSITION FROM ANALYSIS, PER 100,000 PARTS.	
		Recapitulation, Calculated Weights of Dissolved, or Suspended Matters, from the Manufacture—pounds.	Same values proportioned to 100,000 parts of the Drainage-Water.	Organic.	Inorganic.		
PORTON MILL. Manufacture of fine writing-paper,*	U. S. gallons, . 70.700 Pounds water, . 589.300 Containing lbs. impurities, . 168.75 [28.64 to 100,000.]	Organic, 184.0	Organic, 31.21	19.285	34.285	17.14	Suspended.
		Alkaline, 32.8	Alkaline, 5.55			53.57	Dissolved.
		Bleach, 32.0	Bleach, 5.43			70.71	Due to the water.
		Alum, 27.2	Alum, 4.61			28.64	
ESK MILL. Manufacture of fine printing-paper,†	U. S. gallons, . 56.470 Pounds water, . 470.560 Containing lbs. impurities, . 67.24 [14.29 to 100,000.]	Organic, 503.0	Organic, 106.69	19.00	47.14	21.00	Refuse.
		Alkaline, 196.5	Alkaline, 41.68			66.14	Suspended.
		Bleach, 85.15	Bleach, 18.06			87.14	Dissolved.
		Alum, 49.05	Alum, 10.40			14.29	Due to the water.
SPRINGFIELD MILL. Manufacture of printing-paper,†	U. S. gallons, . 16.070 Pounds water, . 133.900 Containing lbs. impurities, . 30.55 [22.82 to 100,000.]	Organic, 767.6	Organic, 568.60	82.04	51.96	72.85	Refuse.
		Alkaline, 213.2	Alkaline, 157.92		36.10	134.00	Suspended.
		Bleach, 91.0	Bleach, 67.41	26.67	101.33	164.10	Chlorine.
		Alum, 3.0	Alum, 2.22				Dissolved.
DALMORE MILL. Manufacture of printing-paper,†	U. S. gallons, . 36.090 Pounds water, . 300.740 Containing lbs. impurities, . 47.2 [15.73 to 100,000.]	Organic, 727.3	Organic, 240.83	43.43	82.43	298.10	Due to the water.
		Alkaline, 295.1	Alkaline, 97.72			22.82	Refuse.
		Bleach, 121.2	Bleach, 40.13			275.28	Suspended.
		Alum, 31.0	Alum, 10.26			59.14	Dissolved.
		1,174.6	388.94			185.00	Due to the water.
						15.73	Refuse.
						169.27	

* The general drainage here is understood to receive of all the liquid refuse.

† The esparto-liquor in this mill is saved, and the soda recovered.

METAL MANUFACTURES.

In comparison with the damage which is inflicted upon river-waters by the sewage of towns and by the drainage from factories devoted to the various branches of industry connected with textile fabrics, the pollution caused by the metal trades, with one or two exceptions, is quite insignificant. This is owing, in the first place, to the circumstance that the greater number of the metal trades are carried on with but very little use of water; and, in the second, to the general absence of organic matters from the waste products arising in the working of metals. The exceptions to this general rule are, notwithstanding, so important, as to deserve careful attention.

The sources of river-pollution brought about by metal-working may be thus classified, viz. :—

1. Pollution by cinders, *scoriæ*, and furnace-ashes.
2. Pollution by acids.
3. Pollution by metallic salts.

The branches of the metal industry which give rise to these forms of river-pollution will be noticed, and some of the specific effects of the noxious refuse shown.

Iron-Works and Rolling-Mills.

The iron-manufacture occupies both in Great Britain and in the United States the leading place among the metal industries. The purely metallurgical operations of smelting, by which the metal is extracted from its ores, are almost necessarily carried on in the immediate vicinity of either the ore, or the coal by which it is to be reduced; the reworking of the metal into articles of general or technical use, is not limited, more than other branches of manufacturing industry, to given localities.

Except for the generation and condensation of steam, water is only incidentally used in iron-works and rolling-mills; chiefly for the purpose of cooling the rolls. The bearings of these rolls are lubricated with tar or coarse grease, some of which is washed away by water along with scales of oxide

from the iron. The amount of pollution thus caused to neighboring streams by works of moderate size is insignificant, as will be seen from the statement of the composition of drainage-water issuing from the Dowlais Iron Works, situated near Merthyr Tydfil in Wales, where 2,000 tons of coal were at the time burnt daily, and about 2,000 tons of iron, beside 700 tons of steel, were manufactured weekly.

Analyses of Water polluted by Iron-Works and Rolling-Mills. Impurities present in 100,000 Parts.

DESCRIPTION.	DISSOLVED MATTER.					SUSPENDED MATTER.		
	Total Dissolved Matter.	Organic Carbon.	Organic Nitrogen.	Chlorine.	Metallic Arsenic.	Mineral.	Organic.	Total.
General drainage from Dowlais Iron Works,*	50.80	.233	.144	1.60	—	4.42	2.30	6.72
Morlais Brook, below Dowlais Iron Works,†	83.74	.104	.029	2.65	.048	8.38	6.40	14.78

* June 20, 1871.

† June 19, 1871.

The consumption of coal at the Dowlais Iron Works is to the net metallic product of the works as $4\frac{1}{2}$ to 1, weight for weight. The following table will show the general composition of the Welsh coal, and at the same time afford a comparison with other more generally known varieties of coal.

Composition of various kinds of Coal.

CONSTITUENTS.	Cannel Coal.	Bituminous Coal.	Welsh or Smokeless Coal.	Anthracite Coal.
Carbon, ...	79.23	82.64	88.66	94.18
Hydrogen, ...	6.08	5.31	4.63	2.99
Oxygen, ...	7.24	5.69	1.03	.76
Nitrogen, ...	1.18	1.35	1.43	.50
Sulphur, ...	1.43	1.24	.33	.59
Ash (mineral matter), .	4.84	3.77	3.92	.98
Total, ...	100.00	100.00	100.00	100.00

The sulphur, which the foregoing analysis shows to be a constituent of coal, is present chiefly in the form of pyrites, which is a compound of sulphur, iron, and a variable but usually small proportion of arsenic.

Of all descriptions of metal-working, the production of iron and steel occasions the largest consumption of coal and presents the most important examples of pollution by cinder-refuse. Works for converting these materials to special uses, —nail-works, foundries, and others of the like class—though conducted upon a smaller scale, are likewise liberal consumers of coal; the ashes and slag from which accumulate upon the premises, even if they do not actually encroach upon the channel of the stream which receives their drainage.

Iron and Steel Wire, and Galvanizing Works.

The metalliferous liquors discharged from works coming under this classification, together with those sometimes allowed to escape in much smaller quantities from brass-foundries, German-silver works, and electro-plate factories, contain metallic salts, which, in all well-regulated works, should be manufactured into marketable products and, sold or disposed of in their crude condition to chemical manufacturers, to be utilized by them.

Of all the forms of river-pollution arising from industries connected with the working of metals which will come under notice, that produced by the waste liquors discharged from wire and galvanizing works is the most intense and noxious. In these operations, iron, in the form of wire or sheet, of nails, and numerous articles of special use, is the metal subjected to treatment.

The process of galvanizing or zincing iron, is thus described :—

Sheet-iron, iron-castings, and various other objects in iron are cleaned and scoured by immersion in a bath of water acidulated with sulphuric acid, heated in a leaden vessel, or used cold in one of wood, in order to remove the oxide. They are then thrown into cold water, and taken out, one at a time, to be scoured with sand and water, with a piece of cork, or more usually with a piece of the husk of the cocoa-nut, the ends of

the fibers of which serve as a brush, and the plates are afterwards thrown into cold water.

Pure zinc, covered with a thick layer of sal-ammoniac to prevent the loss of the metal by oxidation, is then melted in a bath, and the iron, if in sheets, is dipped, several sheets at a time, in a cradle or grating. The sheets are slowly raised to allow the superfluous zinc to drain off, and are thrown whilst hot into cold water, on removal from which they require to be wiped dry.

Thick pieces are heated before immersion, in a reverberatory furnace, to avoid cooling the zinc. Nails and small articles are dipped in acid, and dried in a reverberatory furnace, and thrown together into the zinc, left for one minute, and then taken out slowly with an iron skimmer; they come out in a mass soldered together, and are separated by being reheated in charcoal-powder and shaken about until cold. Wire is reeled through the zinc, into which it is compelled to dip by a fork or other contrivance.

In the operation of steeping, or "pickling," as it is technically termed, iron is subjected to the action of dilute sulphuric or muriatic acid for the purpose of dissolving oxide from the surface of the metal; and as the solution must possess considerable strength to effect this, there is always left in the bath, when it is practically exhausted, a large proportion of free acid. There is also in solution a larger proportion of sulphate or muriate of iron: the first a product of some value, and easily disposed of; the second a compound of considerable repute as a disinfectant, but for which there is only a variable and uncertain market. Muriatic acid seems to be selected in England chiefly because of its superior cheapness in some localities; in the United States, so far as known, sulphuric acid is employed almost exclusively in the processes referred to. It is understood, however, to be the general practice in these works to discharge the waste contents of the acid-baths suddenly into rivers or sewers, as the case may be, rendering the water of the former unfit for the support of fish-life, if not absolutely injurious to the health of man or air-breathing animals, and, by the corrosive action of the free acid, dissolving the cement and loosening the brickwork of the latter.

Wire-works, for the manufacture of iron and steel wire, consume considerable quantities of acid in the "drawing" process. The metal requires to be annealed from time to time, between successive drawings, otherwise it would become too hard and brittle for further extension; to loosen and remove the crust of oxide which forms during the annealing, the coil of wire is "pickled" in dilute sulphuric acid, followed usually by immersion in milk of lime.

Iron-foundries engaged in the manufacture of plows and similar work, also use acid for the loosening and removal from the surface of the castings of a silicious crust or scale which adheres to them from the sand of "unfaced" molds in which the castings have been formed.

Shovel-works, as a distinct branch of the iron and steel industry, consume acid largely, and under the same general conditions as wire-works.

The waste liquors from these various works may be considered as identical in character with those from galvanizing works, already described, containing free sulphuric acid and copperas (sulphate of iron) as their chief ingredients. The chemical composition of the waste liquors from certain wire and galvanizing works is given in the following table:—

Analysis of Waste Liquors from Iron Wire and Galvanizing Works.

[Impurities present in 100,000 parts.]

FIRM, ETC.	DESCRIPTION.	DISSOLVED MATTERS.					SUSPENDED MATTERS.		
		Total Dissolved Matters.	Metallic Iron.	Chlorine.	Sulphuric Acid.	Acidity, equivalent in parts of Muratic Acid.	Mineral.	Organic.	Total Suspended Matters.
Byland Bros., Warrington, Eng., . . .	<i>Wire and Galvanizing Works.</i> General drainage of works, . Washing and pickling vats, .	7,727.	598.69	230.	127.38	601.6	109.	1,431.	1,540.
		2,309.	None.	120.	495.11	None.	172.05	268.5	1,989.
Kings & Newton, Birmingham, Eng., . . .	<i>Galvanizing-Works.</i> Pickling liquor sent to waste (diluted with six parts of water), ...	38,020.	15,023.7	19,750.	447.08	25,192.	Very	turbid.	
Dartmouth Wire Wks, England, ...	<i>Iron-Wire Works.</i> Pickling liquor, ... Drainage of the works, . .	23,945.	7,670.	72.	11,706.8	10,114.4	Very	turbid.	168.08
		1,009.	218.68	44.	383.18	None.	132.52	35.56	

These numbers prove in the most unmistakable manner the strongly acid character of most of these waste liquors; and the injury done by them is greatly intensified if they are suddenly discharged in large volume into either sewers or streams. This nuisance is disposed of in the following manner at a tin-plate works:—

The sheet-iron, previous to receiving its coating of tin, is pickled repeatedly in dilute sulphuric acid, but the waste liquor, instead of being discharged as formerly into the neighboring stream, is concentrated in shallow leaden evaporating-pans, until, on cooling, it deposits a copious crop of crystals of green copperas, which is sold at a small profit; the mother-liquor from these crystals is fortified with fresh sulphuric acid, and used over again, none being allowed to go into the river.

Brass-Foundries and Electro-plate Works.

In the actual founding of brass, water is not used, but in the subsequent treatment of the copper-zinc alloy, there are operations in which acid liquors are employed. Such liquids, when exhausted, consist of salts of copper and zinc dissolved in acid water; they are at least as injurious to sewers and running waters as the waste liquors from galvanizing-works; but being produced in very much smaller quantity, and possessing, bulk for bulk, a much higher value, on account of the copper which they contain, the recovery of the metal is frequently effected, and thus pollution from brass-foundries is comparatively insignificant.

In works for the manufacture of brass and copper tubing, a pickling liquor of dilute sulphuric acid is used to remove the scaly deposits formed upon the surface of the metal in the operation of soldering. A means of recovering the copper from the solution, consists in placing scrap-iron in the exhausted liquor, which replaces the first metal in the chemical combination; the altered liquor, it is to be feared, is then sent to waste. The analysis of a sample of this liquor will be found in the subjoined table.

Composition of Waste Liquors from Brass-Foundries.

[Impurities present in 100,000 parts.]

DESCRIPTION.	DISSOLVED MATTERS.						Suspended Matters.
	Total Dissolved Matters.	METALLIC.			Chlorine.	Sulphuric Acid.	Acidity, equivalent in parts of Muratic Acid.
		Iron.	Copper.	Zinc.			
<i>Brass-Foundries.</i>							
General drainage, ...	55.7	—	—	—	8.5	13.6	—
Waste nitric-acid liquor, ...	8,224.4	—	537.1	379.	42.	—	5,865.6
Washing-water liquor, ...	1,216.	3.64	82.4	39.16	—	—	684.3
<i>Brass-Tube and Wire Works.</i>							
Waste-acid liquor containing sulphate of iron in solution, ...	32,161.	7,285.9	15.96	1,280.6	65.	17,474.	15,792.

* Very turbid.

† Slightly turbid.

In the manufacture of chandeliers, brass is first pickled in dilute nitric acid and then immersed in a dilute solution of nitrate of iron, or of arsenious acid, for the purpose of imparting a copper color, or "bronzing," to the brass, which, after polishing with a kind of red chalk, is browned by being heated in a muffle. The composition of the water in which the brass articles are washed after being removed from the pickling liquor, is also given (see preceding page).

The process of electro-plating is chiefly employed in an industrial sense, in those cases where it is desired to coat an inferior metal or alloy with a film of silver, gold, or nickel, either as a protection from corrosion, or for ornament, or for both purposes.

The metal to be applied is in all cases held in the form of a solution in a bath, in which are also placed the articles to be plated. The dissolved metal is then thrown down by the action of electricity or galvanism upon the surfaces previously prepared for its reception. No waste or pollution of water attends the plating process itself, though in the fabrication of plated ware noxious waste liquors are produced.

In the preparation of the articles intended to receive plating, they are steeped for a short time, sometimes in dilute nitric acid, and sometimes in dilute sulphuric acid, and then polished on a wheel by fine sand, followed by rouge; in other cases a boiling in potash-lye precedes the pickling in acid.

A statement of the composition of the alloys employed by the manufacturers of plated work will explain the character of the metallic salts present in the exhausted pickling liquors. The component metals of the two most extensively used alloys are here given.

Composition of the Alloys.

German (or Nickel) Silver.		Britannia-Metal.	
Copper, ...	57 parts.	Copper, ...	17 parts.
Zinc, ...	19 "	Zinc, ...	8 "
Nickel, ...	24 "	Tin, ...	25 "
		Antimony, ...	25 "
		Bismuth, ...	25 "
Total, ...	100	Total, ...	100

Of these alloys, that known as britannia-metal is believed to be more largely used in the United States, and German-silver and copper in England, for silver-plated manufacture.

After undergoing the plating operation, the articles are partly burnished and partly polished, a mixture of powdered quicklime and oil answering for this purpose.

Neither of these processes requires the use of water.

POISONED WATER — ITS LIMITS.

A great many chemical compounds, some derived from inorganic matters, and others formed in animals or plants, produce peculiar changes in the living animal organisms. They destroy the vital function of individual organs; and, when their action attains to a certain degree of intensity, death is the consequence. The action of inorganic compounds, such as acids, alkalies, metallic oxides, and salts, can, in most cases, be easily explained: they either destroy the continuity of particular organs, or they enter into combination with their substance. The latter is characteristic of true inorganic poisons, a class which includes the principal metallic oxides and salts; such substances as sulphuric, muriatic, and oxalic acids, and hydrate of potash, though violently injurious, or fatal under certain conditions, not being strictly poisons. True inorganic poisons are such through their power of forming permanent compounds with the organic substance of membrane and muscular fiber, in the exercise of a chemical affinity more powerful than the vitality of the organ on which they act.

The effect upon fish of a number of leading and potent polluting substances occurring as manufacturing refuse was subjected to actual test for each substance separately, and for different degrees of intensity, in an elaborate series of experiments carried out in Glasgow, Scotland, in the year 1867, by Messrs. Penny and Adams. The information which was so obtained may be considered invaluable, as affording precise and cogent evidence of the degree of dilution at which the noxious matters prove speedily fatal, and the degree at which they are, so far as observation goes, harmless. Moreover, it

is not known, that apart from these experiments, any records of special investigation into the physiological effects upon fish-life of the class of substances referred to have been anywhere made.

The following facts touching the class of refuse arising from metal-working are selected from the report of the experiments, and fully confirm, it is believed, the results and deductions of previous chemical researches. For purposes of comparison, the action of certain substances not connected with the metal industry are also noticed.

The series of experiments to which reference is had were conducted upon goldfish and minnows as subjects. These two kinds of fish possess different temperaments, the minnow being remarkable for its delicate vitality, and for the fine sensibility it evinces toward all kinds of disturbing influences, the goldfish on the other hand possessing a comparative tenacity of life, and a sluggishness of nature that permits sufficient length of time for observing the action of poisonous agents.

Experiments with Acids.

Of the mineral acids, the nitric and sulphuric were the most powerful, killing fish when present in the proportion of one part to fifty thousand, while, in the same proportion, muriatic acid did not destroy life. Arsenious acid, the well-known poison of arsenic, proved, as was expected, a very deleterious agent: a minnow died in water contaminated with one thirty-five thousandth part, and although the hardy goldfish survived when exposed for twenty hours to a like proportion, there was sufficient evidence that its power of endurance had been fully tested.

Carbolic acid, one of the most active principles of coal-tar, was found peculiarly destructive, its tendency being to kill, like certain of the nervine poisons, by the first shock.

Certain of the vegetable acids exhibited great potency, tannic acid particularly; a minnow was killed by one fourteen thousandth part of this, and a goldfish by one seven thousandth part.

Experiments with Metallic Salts.

Of the metallic salts, by far the most virulent in its properties was the sulphate of copper; a strong fish was killed in water which contained only a proportion of one to one hundred thousand. Sugar of lead, alum, the salts of iron and tin, are all destructive of fish-life, and the proportion in which they prove fatal, about one to four thousand, is nearly alike in all.

The effects of chloride of lime were studied with special interest; it was found that a proportion of one part of a saturated solution of this substance to twenty-one thousand parts of water, was the nearest in which a fish ultimately survived, after having been exposed for some hours to its action. This salt is a powerful irritant, and its local effects are very evident. The fish exposed to its influence soon becomes covered with an exudation of grayish matter, the scales and fins lose their transparency, while mucus and even blood exude from the gills. An almost instantaneous injury results from exposure to a strong solution of it, the fish rarely escaping death.

Experiments with Special Chemicals.

In the group thus named there will be found in each substance a poisonous agency of great power. They are all strongly irritant, and evidently kill by producing a local injury, probably of a corrosive character.

The nearest limit in which a fish lived when exposed in a saturated solution of chlorine, was a proportion of one to two thousand.

Iodine killed with a seventy thousandth part, and bromine was destructive only in a lesser degree.

Caustic potash destroyed a fish when present in a thirty thousandth part.

Experiments with Furnace-Ashes.

Coke, as used in foundries, and also ordinary furnace-cinders, or ashes, were found to constitute a source of danger not previously suspected. Whether discharged in heaps at the banks,

or thrown into the channel of the stream, or furnishing their hurtful influence to the waters through the drainage of rain-washings, they are believed to be the means of inflicting an injury upon fish-life, for which other agencies, perhaps altogether blameless, may be called to bear the responsibility.

The important bearing of this suggestion will be best illustrated by the simple reference to the fact, that in two experiments made with five hundred grains of furnace-ashes to a gallon of water (one one hundred and fortieth part) a minnow died in forty-three minutes, and a vigorous goldfish in five and a half hours.

Results of Experiments on Fish, restated.

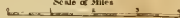
NOXIOUS SUBSTANCES ADDED TO WATER.		Limit at which the Substance proved fatal, Proportionate part.
Acids, ...	{ Sulphuric, ...	$\frac{1}{50000}$
	{ Nitric, ...	$\frac{1}{50000}$
	{ Muriatic, ...	—
	{ Arsenious, (common arsenic), ...	$\frac{1}{35000}$
Metallic salts, ...	{ Sulphate of copper, ...	$\frac{1}{100000}$
	{ Sulphate of iron, ...	$\frac{1}{100000}$
	{ Sulphate of alum, ...	$\frac{1}{100000}$
	{ Acetate of lead, ...	$\frac{1}{4000}$
	{ Chloride of lime, saturated solution, ...	$\frac{1}{16000}$
Special chemicals, ...	{ Chlorine, saturated solution, ...	$\frac{1}{1400}$
	{ Iodine, ...	$\frac{1}{70000}$
	{ Bromine, ...	$\frac{1}{35000}$
	{ Caustic potash, ...	$\frac{1}{30000}$
Coal-products, ...	{ Foundry-coke, ...	$\frac{1}{140}$
	{ Furnace-cinders, ...	$\frac{1}{140}$
	{ Coal-tar, ...	$\frac{1}{8750}$

Valley of Blackstone River

within the State of Massachusetts

Drainage Area 312 Square Miles

Scale of Miles



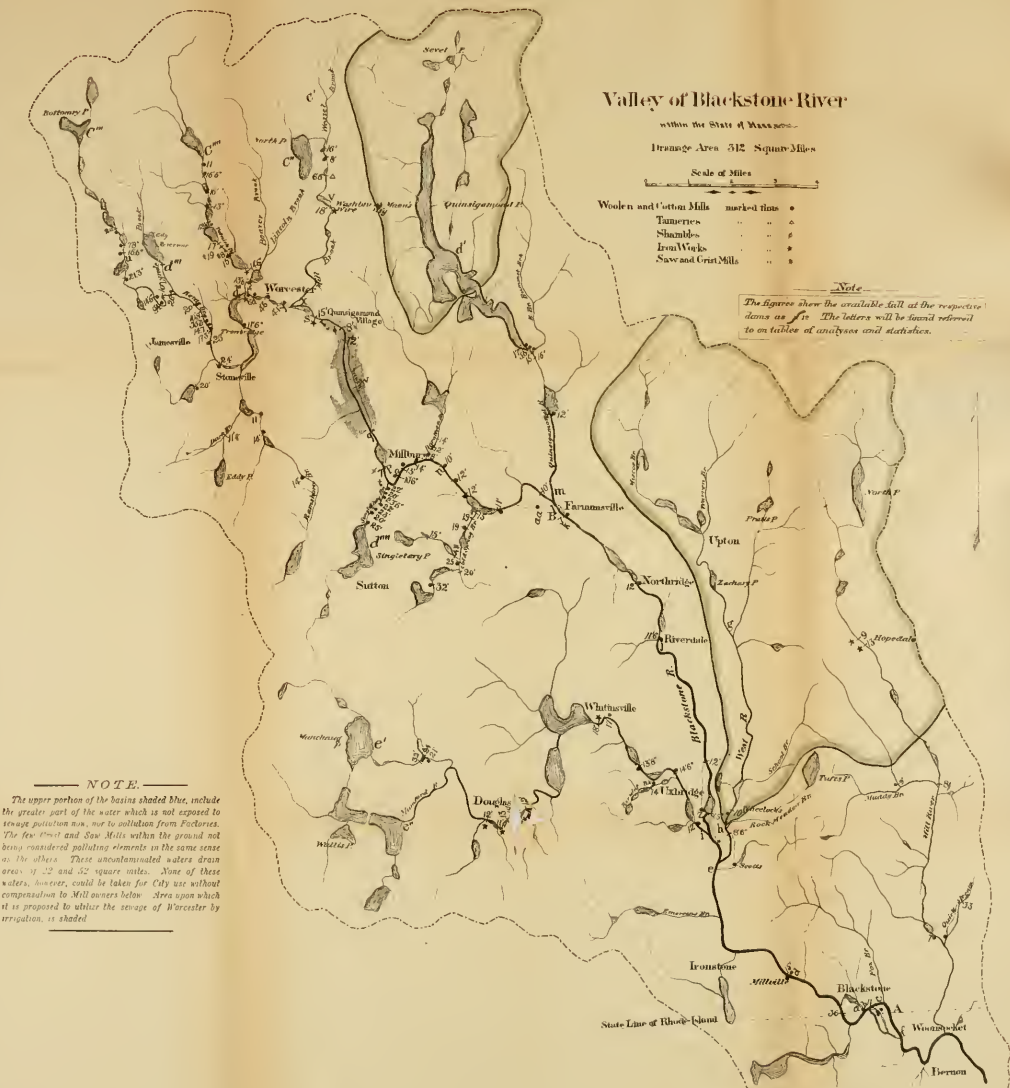
Woolen and Cotton Mills	marked thus	o
Tanneries	"	△
Shambles	"	+
Iron Works	"	*
Saw and Grind Mills	"	■

Note

The figures show the available fall at the respective dams as *ft.* The letters will be found referred to on tables of analyses and statistics.

NOTE.

The upper portion of the basin shaded blue, include the greater part of the water which is not exposed to sewage pollution was, not so isolated from factories. The few small and Saw Mills within the ground not being considered polluting elements in the same sense as the others. These uncontaminated waters drain areas of 22 and 52 square miles. None of these waters, however, could be taken for City use without compensation to Mill owners below. Area upon which it is proposed to abate the sewage of Worcester by irrigation, is shaded.



EXAMINATION OF RIVER-BASINS.

The positions and character of the mills and factories on the rivers examined this season, will now be given, beginning with the "Blackstone."

The following list condenses the information obtained by Mr. E. K. Clark, the assistant engineer; the quantities of materials used at the different factories are given where they could be obtained.

BLACKSTONE RIVER.

Comparing this river, which is probably more polluted than any other in Massachusetts, with the English rivers given in the general table, it will be seen that the population of the valley is greater per square mile than that of the Thames valley above Hampton; and that the number of mills and factories referred also to the same measure is three times greater. The converse would be true, however, if we used for comparison some of the rivers of the manufacturing districts in England, as the Mersey and others.

By means of the index letters and names, the reader will be able to trace the list upon the map.

Mills, Factories, etc., in the Blackstone River Valley.

NAME OF STREAM OR RIVER.	Letters corresponding with Letters on Map.	DESCRIPTION OF MILL.	Location.	No. of Hands Employed.	No. of Spindles.	Head and Fall.	Sets of Machinery.	Quantities of Material used per year, so far as known.
Blackstone River,	A	Dellebar & Mason, Woolen Mill.	Blackstone,	210	-	Ft. 11	12	168 tons logwood, 182 bbls. oil, 20 bbls. urine, small amount ammonia.
	b	Evans, Legrave & Co., Woolen Mill.	Blackstone,	200	-	11	-	40 tons logwood, 3,000 lbs. madder, 75 bbls. oil, 15 bbls. urine, 6,000 lbs. copperas.
	a d	Blackstone Cotton M'f'g Co., Hanson, Bliss & Co., Woolen Mill.*	Blackstone, Millville,	1,000	52,000	36	-	20,000 lbs. wool, 12 bbls. oil.
		Wilcox & Aldrich, Flock Mill,*	Millville,	65	-	15	-	
		Fred. Thayer, Shoddy Mill,*	Millville,	20	-	12	-	
	z	Uxbridge Woolen Mill,	Millville,	4	-	12	-	
	j	Central Woolen Mill,	Uxbridge,	170	-	8	12	30 tons logwood, 9 tons soda-ash, a little oil of vitriol, ammonia and madder.
		Paul Whitting & Co., Cotton M'f'g, "Riverdale Mills,"	Uxbridge,	150	-	12	10	30 tons logwood, 9 tons soda-ash, 75 bbls. oil, 1 ton madder.
	k	Rockdale Mills, Cotton,	Northbridge,	98	6,456	11	-	22,880 lbs. cotton.
	B	Farnumsville Cotton Mill,	Northbridge,	140	10,568	12	-	405,000 lbs. cotton.
		Fisherville Cotton Mill,	Grafton,	70	5,952	7	-	286,000 lbs. cotton.
		Saundersville Cotton Mill,	Grafton,	112	5,500	10	-	444,600 lbs. cotton.
		Sutton Cotton Man'f'g Co.,	Grafton,	130	12,000	11	-	372,800 lbs. cotton.
			Sutton,	150	9,424	12	-	360,221 lbs. cotton.

Mills, Factories, etc., in the Blackstone River Valley—Continued.

NAME OF RIVER OR STREAM.	Letters correspond- ing with Letters on Map.	DESCRIPTION OF MILL.	Location.	No. of Hands Em- ployed.	No. of Spindles.	Head and Fall.	Sets of Machinery.	Quantities of Material used per year, so far as known.
Kettle Brook, . .		Stoneville Cotton Mill,†	Anburn, .	75	-	Ft. In. 24	-	
		Tape Manufacturing,†	Anburn, .	50	-	24	-	
		Jamesville Woolen Mill, .	Worcester, .	90	-	23	-	
		Hunt's Woolea Mill, .	Worcester, .	30	-	17 3	-	120,000 lbs. woolen material, small quan- tity soda-ash, logwood, oxalic acid.
		Darling's Woolen Mill, .	Worcester, .	23	-	14 7	2	120,000 woolen material.
		Ashworth & Jones, Woolen Mill,	Worcester, .	80	-	35 6	4	240,000 lbs. woolen material.
		Wright Bottomly Shoddy Mill,	Leicester, .	30	-	10 8	-	12,000 lbs. soda-ash.
		Smith Woolen Mill, .	Leicester, .	100	-	20	4	150,000 lbs. wool, 18,000 lbs. soda-ash.
		Geo. W. Olney, Woolen Mill, .	Leicester, .	60	-	26	6	132,000 lbs. wool, 5,750 lbs. soda-ash, 70 bbls. soap.
		Unoccupied privilege, .	Leicester, .	-	-	10	-	
		Dickinson's Woolen Mill, .	Leicester, .	9	-	9 4	1	} The two mills belong to one party, and use 210,000 lbs. woolen material.
		Chapel Woolen Mill, .	Leicester, .	23	-	14 6	2	
		Booth Bottomly Woolen Mill, E. D. Thayer.	Leicester, .	90	-	21 3	4	210,000 lbs. woolen material, 15,000 lbs. soda-ash, 1,650 lbs. logwood.
	n	Thayer's Shoddy Mill, .	Leicester, .	3	-	16 6	-	

Kettle Brook, .	Kent's Shoddy Mill, .	Leicester, .	8	-	7	8	-	150,000 lbs. woolen material, 1,300 lbs. soda-ash, 5 bbls. soap.
Ramshorn Brook, .	Mann & Marshall, Woolen Mill,	Leicester, .	22	-	20	-	-	150,000 lbs. woolen material, 1,300 lbs. soda-ash, 5 bbls. soap.
	Dunn's Shoddy Mill, .	Millbury, .	3	-	11	-	-	270,000 lbs. woolen material, 15,000 lbs. soap.
	Leonard's Woolen Mill, .	Auburn, .	56	-	14	-	-	One stone.
	Wood's Cotton M l, .	W. Millbury, .	40	-	25	-	-	167,000 lbs. cotton.
Dark Brook, .	Grist Mill, ...	W. Millbury, .	-	-	11	-	-	15,000 lbs. cotton, 20,000 lbs. wool.
Singletary Brook, .	John Rhodes, Cotton Mill, .	Millbury, .	30	2,000	22	-	10	300,000 lbs. wool, 24 tons logwood, 10,800 lbs. soda-ash, 1,000 lbs. copperas.
	Crane & Waters, Stocking Factory,	Millbury, .	125	-	20	-	-	150,000 lbs. cotton.
	Walling Woolen Mill, .	Millbury, .	120	-	23	6	7	300,000 lbs. wool, 24 tons logwood, 10,800 lbs. soda-ash, 1,000 lbs. copperas.
	Bramanville Cotton Mill, .	Millbury, .	55	-	22	-	-	150,000 lbs. cotton.
t	Eagle Woolen Mill, . .	Millbury, .	120	-	23	-	-	300,000 lbs. wool, 24 tons logwood, 24,000 lbs. soap.
	Crane & Waters, Cotton Mill, .	Millbury, .	53	3,768	20	-	-	140,400 lbs. cotton.
	Wheeler Cotton Mill, .	Millbury, .	55	-	25	-	-	280,800 lbs. cotton.
	A. G. Coes, Iron Wrench M'f'g,*	Worcester, .	50	-	13	6	-	Small quantity of acid used in pickling.
d''	Row & Culver, Iron Pat. Shears,*	Worcester, .	4	-	-	-	-	24 carboys of acid in pickling iron-work.
	John Dean & Co., M'f'g daguer-type goods,*	Worcester, .	3	-	-	-	-	
	Loring Coes, Machine-shop, .	Worcester, .	40	-	14	6	-	
	Loring Coes, Edge Tools, .	Worcester, .	9	-	15	-	-	
	W. C. Smith, Wood-work, .	Worcester, .	10	-	8	-	-	

* At one dam.

† At same dam.

Mills, Factories, etc., in the Blackstone River Valley—Continued.

NAME OF RIVER OR STREAM.	Letters correspond- ing with Letters on Map.	DESCRIPTION OF MILL.	Location.	No. of Hands Em- ployed.	No. of Spindles.	Head and Fall.	Sets of Machinery.	Quantities of Material used per year, so far as known.
Tarnick Brook,	.	W. W. Patch, Grist Mill, .	Worcester, .	2	-	Ft. In. 19	-	Three stones.
	.	Reservoir Dam, .	Worcester, .	-	-	17	-	
	.	Safinet Mill, H. F. Butler, .	Worcester, .	13	-	12 6	-	120,000 lbs. woolen stock.
	.	A. L. Whiting, File Mannuf'g, .	Worcester, .	11	-	13	-	
	.	Pond's Reservoir Dam, .	Worcester, .	-	-	16	-	
	.	St. George's Blanket Factory, .	Worcester, .	6	-	16 6	-	60,000 lbs. stock.
	.	Shoddy Mill, ...	Worcester, .	2	-	11	-	
	.	Wire Mannuf'g, ...	Worcester, .	500	-	18	-	
	.	Warren's Tannery, ...	Worcester, .	6	-	6 6	-	Tan 1,800 hides.
	.	Buttrick's Yarn Factory, Cotton, Daniels & Son, Cotton Mill, .	Worcester, .	10	-	8	-	75,000 lbs. cotton.
Dorothea Brook,	.	Chamberlain's Wood Washing Establishment.	Millbury, .	30	-	8	-	Cleanse 120,000 lbs. wool; use 31,200 lbs. soda-ash, 150 bushels salt.
	.	Grist Mill, ...	Millbury, .	1	-	12	-	
	.	Machine-shop, ...	Millbury, .	5	-	14	-	

Quinsigamond River,	m	Quaker Cotton Mill, .	Grafton, .	50	3,500	12	-	180,000 lbs. cotton.
		Grist Mill, .	N. England Vill.,	-	-	16	-	-
		Grafton Cotton Mills,*	N. England Vill.,	250	12,000	15	-	-
		Grafton Cotton Mills,	N. England Vill.,	-	-	5 6	-	-
		Grafton Cotton Mills,	N. England Vill.,	-	-	17	-	-
	d	Shuttle Manuf'g, .	Sutton, .	18	-	15	-	-
		Grist Mill, .	Sutton, .	1	-	19	-	-
		Woolen Mill,†	Sutton, .	35	-	19	2	156,000 lbs. woollen material.
		Box Factory, .	Sutton, .	2	-	41 2	-	-
		Shuttle Man'f'g, .	Sutton, .	-	-	15	-	-
		Flock Mill, .	Sutton, .	3	-	25	-	-
		Unoccupied privilege,	Sutton, .	-	-	20	-	-
		Flock Mill, .	Sutton, .	3	-	32	-	-
		Capron Woolen Mill,†	Uxbridge, .	80	-	12	5	50,000 lbs. wool, 7,000 lbs. logwood, 2,500 lbs. soda-ash.
		Shoddy Mill,†	Uxbridge, .	12	-	-	-	-
		Uxbridge Cotton Mill,	Uxbridge, .	140	10,192	14 6	-	-
		Linwood Cotton Mill,	Uxbridge, .	200	15,000	13 8	-	624,000 lbs. cotton.
		Whitinsville Cotton Mill,	Northbridge, .	200	12,336	17	-	600,000 lbs. cotton.

* Upon three privileges.

† Δ short distance above this mill, the brook divides.

† At same dam.

Mills, Factories, etc., in the Blackstone River Valley—Continued.

NAME OF STREAM OR RIVER	Letters corresponding with Letters on Map.	DESCRIPTION OF MILL.	Location.	No. of Hands Employed.	No. of Spindles.	Head and Fall.	Sets of Machinery.	Quantities of Material used per year, so far as known.
Mumford River,	.	Whiting Machine Co.,	Northbridge,	450	-	Ft. In. 18	-	350 lbs. vitriol per day for pickling castings.
		Douglas Axe Man'g,	Douglas,	-	-	12	-	
		Douglas Axe Man'g,	Douglas,	-	-	18	-	
		Shoddy Mill,	Douglas,	4	-	13	-	
		Douglas Axe Man'g,	Douglas,	-	-	11	-	
		Douglas Axe Man'g,	Douglas,	300	-	12	-	
		Manchang Cotton Mills,	Sutton,	-	-	21	-	
		Manchang Cotton Mills,	Sutton,	-	-	24	-	
		Manchang Cotton Mills,	Sutton,	620	46,000	32	-	1,800,000 lbs. cotton.
Rivulette Brook,	.	Rivulette Cotton Mill,	Uxbridge,	50	-	14	-	
West River,	.	Scott's Woolen Mill,	Uxbridge,	30	-	8 6	2	Two tons logwood, 12,000 lbs. soda-ash, 500 lbs. soap, 500 lbs. blue vitriol.
		Wheelock's Woolen Mill,	Uxbridge,	80	-	10	5	30 tons logwood, 12,000 lbs. soda-ash, 1,500 gal. oil, 60 lbs. soap.
Mill River,	.	Gatchel's Yarn Factory,	East Blackstone,	16	-	7	-	124,800 lbs. cotton.
Quick Stream,	.	Yarn Factory,	East Blackstone,	13	-	33	-	100,000 lbs. cotton.

Mill River, . . .	Box Factory, . . .	East Blackstone,	5	-	8	-
Muddy Brook, . .	Flock Mill, . . .	East Blackstone,	3	-	9	-
Mill River, . . .	Hopedale Machine Co., . .	Hopedale, . .	150	-	9	-
	Dutcher, Temple & Co., Machine-shop.	Hopedale, . .	75	-	13	-
	<i>Woolen Mills using Steam power.</i>					
	Worcester Felt Co., . . .	Worcester, . .	35	-	-	-
	Worcester Woolen Co., . .	Worcester, . .	200	-	12	-
	Adriatic Woolen Mills, . .	Worcester, . .	230	-	14	-
			Use \$500 or \$600 worth of dyestuffs per month, 270,000 lbs. material.			
			300,000 lbs. woolen material.			
			600,000 lbs. woolen material.			

Summary for Blackstone River.

	Number.	Operatives Employed.
Woolen Mills, ...	44	3,003
Cotton Mills, ...	27	3,978
Iron Works, ...	12	1,224
Tanneries, ...	1	6
Shambles, ...	1	5
	85	8,216

NOTE.—Saw and Grist Mills are not considered polluting.

ANALYSIS OF STATISTICS.

The following table will explain itself. The examples there given, if compared with the analyses of the water taken from the same points, may enable the reader to understand under what circumstances that analysis exposes the previous contaminations received up stream.

BLACKSTONE RIVER.—This table is intended to explain the rate of dry-weather flow of the stream and the amount of its previous exposure at a few of the points whence water was taken for analyses. The points are indicated by the same letters on the map, and also on the tables of analyses.

SEE THE POSITIONS OF THE SAME LETTERS ON THE MAP, ...	A	B	C	D	E	F	G
Drainage-area above the point indicated by each letter in square miles, ...	276	138	252.7	57.7	33.5	75.3	
Dry-weather flow at respective points in 24 hours, cubic feet, ...	5,961,600	2,980,800	5,458,320	1,246,320	723,600	1,626,480	
Dry-weather flow at respective points in U. S. gallons, ...	44,592,768	22,296,384	40,828,233	9,322,473	5,412,528	12,164,070	
Number of polluting factories or mills, ...	85	62	79	10	1	41	
Number of polluting factories or mills per square mile, ...	0.3	0.44	0.31	0.173	0.03	0.5	
Number of operatives in said mills, ...	8,216	4,023	6,717	2,056	80	2,319	
Population above respective points, 1875, ...	80,638	61,294	75,598	7,148	5,704	49,465	
Population above respective points per square mile, ...	292.1	444.1	299.1	123.8	170.2	656.9	
Population above respective points, 1870, ...	71,248	54,080	65,527	6,319	4,525	41,305	
Population of cities, villages, or mills now sewerage into river above said points, ...	55,050	50,900	54,550	2,700	400	48,500	
Population of this character per square mile, ...	199	369	216	46	12	644	

Samples of water were taken from twenty-seven different points. They were sent to Prof. W. Ripley Nichols for examination. The analysis of these waters will be found, as tabulated by him, at the end of this statement.

It may be more profitable here to call the reader's attention to a few of these, than to present the whole in this place.

The following extract (see Table, p. 85), therefore, gives only the head waters not exposed to any pollution, the water from that part of the river where the pollution is most concentrated, and the water from the lowest point of the river at Blackstone.

The water of Mill Brook, after it has received the sewage of Worcester, is shown to be very impure in this table, and on the Blackstone River, at the sash factory, about five miles lower down, it still gives unmistakable signs of the influence of this pollution; but at Blackstone, twenty-five miles below Mill Brook, the dilution produced by numerous small streams delivering into the main river between these points has all but obliterated the evidence of impurity, so far as analyses can expose it; the only marked difference here in the table between the water at Blackstone and the head water of the river, being in the amount of chlorine, the increase, however, of this evidence of impurity not being so great as to condemn the water (by this test) for domestic or any other use. It is to be noted, however, that the river at this time was not at its very low dry-weather stage, which usually occurs in October or November, when it occurs at all. In extreme low water, the river would give greater tokens of impurity.

Of the samples of water received by Prof. Nichols, which were taken from all parts of the Blackstone Valley, he says:—

"The waters were all alkaline; as a rule, they were not so strongly colored as those from the Chicopee, Taunton, etc. The samples taken from the upper parts of the river showed evidence of considerable sewage-contamination. Some of them contained a marked amount of suspended matter, which amount was determined in a few cases. A disagreeable odor was also perceptible in some of the specimens."

Analysis of the Waters of the Blackstone River Valley.

[Parts per 100,000.]

DATE.	Letters on Map.	LOCALITY.	Ammonia.	"Albuminoid Ammonia."	SOLID RESIDUE.		Chlorine.	Oxygen required.
					Organic.	Total.		
Sept. 10, 1875,	C"	North Pond above pollution, ...	.0107	.0213	1.80	4.20	.18	0.588
Sept. 11, 1875,	d'	Lake Quinsigamond—middle, ...	.0037	.0157	1.56	3.84	0.14	0.304
Sept. 14, 1875,	d'''	City Reservoir—gate-house, ...	.0072	.0235	1.96	3.76	0.12	0.500
July 29, 1875,	p	Mill Brook near Blackstone River, ...	.9600	.1109	4.96	23.44	3.80	1.098
		Blackstone River, sash factory, ...	.0992	.0307	3.20	8.04	0.92	0.429
July 10, 1875,	A	Blackstone River below Blackstone Mills, ...	.0099	.0139	1.64	4.80	0.38	-
July 10, 1875,		Blackstone River below dam at Blackstone, ...	.0157	.0163	1.40	4.60	0.36	-

The following additional notes by Mr. E. K. Clark, assistant engineer, who collected the statistics of the Blackstone River Valley, throw some further light on the present condition of its waters:—

"*Blackstone Village* (population, 4,640). The sewage of Blackstone does not flow directly into the river, nearly all the houses being connected with cesspools. From the mills, and a few of the houses along the banks of the river, refuse is discharged directly into the water. The water was quite high in the spring of 1867."

"*Uxbridge* (population 3,026) has no system of sewerage. A part of the houses of the town, with the mills, send the sewage directly into the water. The land is favorably situated for a large amount of surface-drainage reaching the river."

"*Northbridge* (population 4,030), Rockdale Mills, Blackstone River. The superintendent of this mill thinks that the same variety of fish may be found in the river a short distance below here, but in comparatively small numbers. The chevin is not seen here at all, and the pickerel rarely."

"Complaint is made of the bad condition of the water in the summer, and of the disagreeable odor. The water here is quite different in appearance from that a few miles below. At Farnumsville the young fish are found dead in places when the water is quiet, and are also caught from the screens. Formerly the fish could be taken in nets, but owing to the turbid condition of the water, they are never taken in that way now. Even when caught, the fish are not considered good to eat. Horses refuse to drink the water in summer."

"At Simpson's woolen mills, Millbury, the water is so bad that it cannot be used for scouring, and it is necessary to send the wool away to be cleansed. Persons obliged to work in the water for any length of time find that they suffer in health. From Millbury to Worcester, the water is in very bad condition, particularly after a rain. When the water is used for steam purposes, it is necessary to leach it to prevent foaming in the boiler. At Millbury Cotton Mill, persons cannot work in the lower rooms of the mill during the hot weather, because of the bad odor coming from the

water. At some of the mills, water is pumped into tanks from the river; filth is deposited in considerable quantity in these tanks. Sample No. 30 was taken from a tank in Morse's mill, in Millbury. Millbury has a population of 4,529, but has no system of sewerage. The sewage from a part of the houses and all the mills flows directly into the Blackstone River and Singletary Brook. Singletary Brook has its rise in Singletary Pond, the water of which is very pure and clear. The pond makes a natural storage-basin for the water. From the mills, at the lower part of the brook, there is complaint that the water is rendered bad for dyeing purposes by the mills above; it also gives trouble in the steam boilers."

"Ramshorn Brook rises in a country considerably elevated above Kettle Brook, to which it is tributary; land free from limestone, and favorable for farming. Mumford River is controlled by the large storage-reservoirs at the head; the mills seldom have trouble from high water. Rock at head of the river is wholly granite. West River rises in Upton; hills at its source quite high, and wholly granite. Mill River; country at the source very much broken; ledges are wholly granite."

"*City of Worcester.*—Worcester is supplied with water from Lynde Brook. For an additional supply, it is proposed to take Kettle Brook or Tatnick Brook. Careful measurements of the volume of water used by the city have not been made, but it is estimated that the 36,000 water consumers (the whole population being 49,268) are now using about 3,000,000 gallons per day. More than 500 meters are placed in dwellings, and the quantity of water so measured indicates a small consumption for domestic purposes; while the amount used by manufactories, measured in the same way, is more than half the daily supply. The volume of water flowing from the sewers of the city in dry weather would be nearly 2,000,000* gallons in twenty-four hours. Nearly all the sewage flows into Mill Brook, and thence into Blackstone River; a small amount, however, from the west side of the city, reaches the river through Beaver Brook; this might without difficulty be directed into Mill Brook.

*A large amount of water is supplied to railroads, and does not pass off by the sewers, being carried away by the locomotives.

In addition to the sewage of the city, Mill Brook has a dry-weather flow of 4,198,000 gallons per day, as measured in 1871, at a point above where the city empties its sewage."

"Below Worcester the country seems to be finely adapted for the purpose of sewage-irrigation, or filtration. On both sides of the river the interval is quite wide, and soil of sandy nature. The higher land is gradually undulating; soil mostly loam and gravel, with very little if any clay. The character of the soil, position, and inclination of the land, and the convenience with which the sewage may be brought to it, seem to give to this section peculiar advantages for utilizing sewage. The surface of water where Mill Brook joins the Blackstone River, is 438 feet above tide-water; the reservoir on Lynde Brook is 828 feet above tide-water; and Catholic College Hill is 693 feet above tide-water. The valley of the Blackstone is entirely free from limestone; the rock is almost wholly granite, particularly about the head waters. The land about the head of West River is quite high, and in some cases bold in its slopes."

"About Worcester the country is considerably broken, and some of the hills have quite a height; the ascent is, however, usually gradual. The color of the water below the point where it would seem to be influenced by the sewage from Worcester, is light brown, and clear. It is not difficult to trace the sewage of Worcester by the color of the water alone for seven miles at least below the city."

NEPONSET RIVER.

The manner in which the water-power of the Neponset River Valley is occupied, will now be described. The following list, in tabular form (see Table, pp. 90-93), comprises the mills, factories, and other works on the stream of this valley, as noted this season on the ground by Mr. C. D. Ward, assistant engineer.

The number of manufacturing establishments on this stream is in much larger proportion than on the Blackstone, when compared with the area of that valley. Mr. Ward adds the following notes :—

"None of the villages are sewered. At Canton seventeen tenements have water-closets and drains that connect with the river. The village of Hyde Park, with a population of five or six thousand, has no sewers to mention, neither does there appear to be any land in the vicinity suitable for irrigation."

"*Minerals, rocks, etc.*—The surface of the country is generally rolling, the highest hill, Blue Hill, having an elevation of 635 feet above tide; the other hills are much lower. Between the points B and C there is a long and wide extent of level and wet meadow called Purgatory Swamp. The rocks are generally igneous or slaty in their nature. At the south-eastern corner of the town of Medfield, not far from the village of Walpole, there is a limited tract of limestone, which is marked on the map. There was at one time a lime-kiln in operation there. There are also slight traces of iron in the vicinity of Walpole."

"*Water and Fish.*—Water is not taken by any village from the river for domestic use. At Walpole there are complaints made that the mills and factories in that vicinity have polluted the river to such an extent that the fish have been killed. In other parts of the river pickerel, perch, eels, bull-pouts, sunfish, and suckers abound. Horses and cattle drink the water in all parts of the river."

River Statistics of Neponset Valley.

NAME OF STREAM OR RIVER.	Letters corresponding with Map.	DESCRIPTION OF MILL.	Location.	No. of Hands Employed.	Head and Fall.	Quantities of Materials Used, &c.
Pine-Tree Brook, Neponset River, .	A	Davis Wool-Pulling Mill, ... Eagle Paper Mill, ... Fuller Paper Mill, ... Mattapan Paper Mill, ... Hyde Park Woolen Mill (steam), ... Brainard Milling Machine Co. (steam), Smithfield Man'g Co. Cotton Mill, ... Wahut Hill Woolen Mill, ... Saw Mill, ... Merchants' Woolen Mill, ... Woolen Scouring-house, ... Dedham Gas Works; supply also Hyde Park.	Milton, ... "Lower Mill," Mattapan, ... Hyde Park, ... Hyde Park, ... Hyde Park, ... Readville, ... Mill Village, ... Mill Village, ... Mill Village, ... Mill Village, ... Mill Village, ...	3 35 55 50 325 50 150 125 - 550 - -	Feet. - 12 8 8 - - 6 10 10 10 5½ -	Some lime used. Make two tons of book-paper a day from rags. Make one ton of cover-paper a day from rags. Make two tons of lithographic-paper a day from rags. 21 sets of machinery. Not started yet. To make cassimeres. 12,900 spindles. Seven sets machinery. Fancy cassimeres. 29 sets of machinery. Beavers and cassimeres. Use 600 tons of coal a year, say 5,000,000 cu. ft. gas.
Mother Brook, .	a ¹ a ²					
Neponset River, .	a ³ B	Glover & Willcomb, Curled Hair Fact'y,	Mill Village, .	60	-	Use some logwood, coppers, and sugar of lead. Classified on map with bleachers and dyers.

Branch, Massapoag Brook,	Canton Woolen Mill (steam),	Canton,	300	-	Use 6,000 lbs. muriatic acid a year and aniline colors; make jackets, shawls, etc. 10,000 spindles.
	Neponset Cotton Factory,	Canton,	175	16	
	Neponset Cotton Factory, Rosin Gas Works.	Canton,	-	-	100,000 c. ft. gas a year.
Beaver Brook,	Read Hardware M'f'g Co.,	Canton,	50	27	
	Chas. Draper, Knitting Mill,	Canton,	75	18	Cotton and woollen cardigan jackets.
Steep Brook,	Joshua Brittain, Awl Factory,	Stoughton,	6	10	
	C. Southworth, Cotton and Woollen Yarn,	Stoughton,	14	14	Three sets machinery.
	L. & G. Southworth, Iron Screws,	Stoughton,	6	10	
	French & Ward's Woollen Mill,	Stoughton,	200	20	Six sets machinery; make cardigan jackets, etc.
	A. Southworth & Co., Cotton Mill,	Stoughton,	12	12	500 spindles; make twine, etc.
Massapoag Brook,	American Net & Twine Co.,	Canton,	50	24	Mostly twisting.
	G. H. Mansfield & Co.,	Canton,	12	6	Fish-line and lamp-wick.
	Seavey, Foster & Bowman, Silk Mill,	Canton,	150	6	Color 1,700 lbs. a week.
	Seavey, Foster & Bowman, Silk Mill,	Canton,	100	11	No coloring here.
	Kinsley Iron & Machine Co.,	Canton,	225	14	
	Ames Shovel Works,	Canton,	24	13	
Beaver Brook,	Lothrop Trowel Factory,	Sharon,	14	7	
Massapoag Brook,	Revere Copper Co., Refining and Rolling,	Canton,	80	20	Use 3 carboys of sulphuric acid a month.
	Mann's Belting Duck Mill,	Sharon,	25	23	1,280 spindles; make 30,000 lbs. a week of duck.
	Lathrop's Cutlery Factory,	Sharon,	25	18	

River Statistics of Neponset Valley—Continued.

NAME OF STREAM OR RIVER.	Letters corresponding with Map.	DESCRIPTION OF MILL.	Location.	No. of Hands Employed.	Head and Fall.	Quantities of Materials Used, &c.
Massapoag Brook,		Lathrop's Cutlery Factory, . . .	Sharon, .	20	Feet. 14	
Branch, . .		Lyman Smith's Sons, Tannery, . .	S. Dedham, .	50	-	300,000 sheep-skins a year. *
Neponset River, .		Geo. Morrill, Printing-Ink Factory, .	E. Walpole, .	12	7	No pollution.
		Geo. Morrill, Gas Works, . . .	E. Walpole, .	2 ²	-	31,000 c. ft. gas from coal.
Budding Brook, .		Winslow Brothers, Tannery, . . .	E. Walpole, .	70	10	400,000 sheep-skins a year.
		Isaac Ellis & Co., Paper Mill, . . .	E. Walpole, .	12	18	Make one ton of binders' boards a day.
Neponset River, .	C ¹	H. W. Tilton, Foundry (not working), .	Walpole, .	-	8	
		H. W. Tilton, Spring Factory, . . .	Walpole, .	50	9	
		F. W. Bird, Wrapping-Paper, . . .	Walpole, .	20	17	1½ tons made a day.
		Hollingwood, Wrapping-Paper, . .	Walpole, .	7	12	One ton made a day.
		F. Morse, Grist Mill, . . .	Walpole, .	3	14	One run of stone.
	C ²	Ira Gill, Felt Hat Man'fy, . . .	Walpole, .	24	12	Make 60 doz. a day. Dye very few.
Spring Brook, .		Diamond Twine and Canvas Factory, .	Walpole, .	6	15	500 spindles.
Neponset River, .		B. Lewis, Steam Cotton Waste Cleansing,	Walpole, .	28	-	Use soda-ash and bleaching-powders; cleanse 670 tons a year.

Mill Brook, . .	E. Frank Lewis & Co., Wool Sorting,	Walpole, . .	12	11	4,000 lbs. wool a day; use 5,000 lbs. of alkalis a year.
Neponset River, .	Willard Lewis, Cotton Bating Mill,	Walpole, . .	70	10	Two tons a day. Dust and dirt sold for manure.
	Walpole Color Works, ...	Walpole, . .	13	-	Made from chemicals; weak tannic and sulphuric acid run away from the works.
	S. Gray & Co., Bleachers and Dyers,	Walpole, . .	12	-	80,000 lbs. bleaching and 130,000 lbs. dyeing done a year; logwood, bleaching-powders and aniline colors used.
	J. B. Cram, Hair Curling Factory, .	Walpole, . .	24	19	Curl 225 tons a year; use 3,600 lbs. logwood, 1,200 lbs. sugar of lead, 3,600 lbs. copperas, and 2,400 lbs. soap a year.
	Blackburn's Foundry, ...	Walpole, . .	-	9	Not used for years.
Branch, . .	Wm. Cary, Jr., Shoddy Mill, . .	S. Walpole, .	3	10	Manufacture one ton a week.
Neponset River, .	Clark's Woolen Mill, ...	S. Walpole, .	18	19	Make 62,000 lbs. woolen yarn a year; three sets of machinery; use 1,000 lbs. soda-ash a year.
	Wm. H. French, Shoddy Mill, . .	S. Walpole, .	3	11	

d

Summary for Neponset Valley.

	Number.	Operatives Employed.
Woolen Mills, ...	11	1,559
Cotton Mills, ...	11	609
Machine-Shops and Foundries, ...	12	562
Silk Factories, ...	2	250
Paper Mills, ...	6	179
Tanneries, ...	2	120
Bleaching and Dyeing, ...	1	12
Chemical Works and Curled Hair, ...	2	37
Gas-Works, ...	3	—
Grist and Saw Mills, ...	2	—
Total, ...	52	3,328

ANALYSIS OF STATISTICS.

The two following tables give the general statistics of a few of the leading points on the streams of the Neponset Valley, for comparison with the results of the analysis of waters taken from the same points, and from the head waters, before they are exposed to pollution.

Summary for certain points in the Neponset Valley.

SEE THE POSITIONS OF THESE LETTERS ON THE MAP, ...	A	B	C	c ¹	c ²	d
Drainage-area in square miles above the point indicated, ...	116	99.5	77.5	30.0	24.5	5.0
Dry-weather flow in 24 hours at respective points in cubic feet, ...	3,271,104	1,719,360	1,339,200	518,400	423,360	86,400
Dry-weather flow at respective points in U. S. gallons, ...	24,467,857	12,860,812	10,017,216	3,877,632	3,166,732	646,272
Number of polluting factories or mills, ...	52	42	40	16	12	-
The same per square mile, ...	0.45	0.42	0.52	0.53	0.49	-
Number of operatives in said factories, mills, etc., ...	3,388	2,045	1,685	290	213	-
Population in basin above the respective points in 1875, ...	23,413	13,273	12,331	2,428	1,975	175
Population in basin above the respective points per square mile, ...	201.84	132.49	159.11	80.90	80.61	35.00
Population of cities, villages, mills, or works now sewerage into the river above said points, ...	2,751	1,533	1,473	215	158	-
Population of this character per square mile, ...	23.72	15.41	19.01	7.17	6.45	-

NOTE.—The flow between A and B (see map), is augmented by a draft from the Charles River through "Mother Brook." The amount which can be withdrawn in this way from Charles River is limited to one-third of its flow.

Analysis of the Waters of the Neponset River, taken from the points indicated in the previous Table.

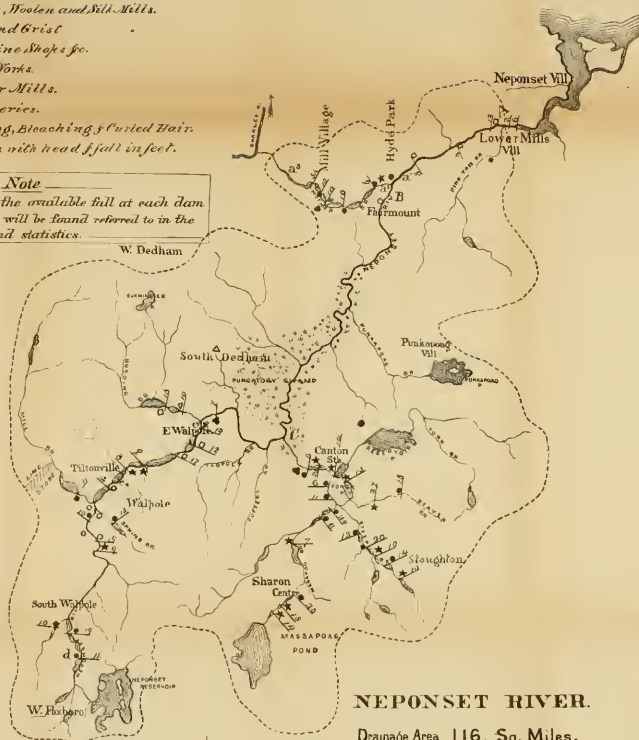
[Parts per 100,000.]

DATE.	Letters on Map.	LOCALITY.	Ammonia.	"Albuminoid Ammonia."	Solid Residue.		Chlorine.	Oxygen required.
					Organic.	Total.		
July 28, 1875,	d	S. Walpole above all pollution, .	.0091	.0325	2.52	4.40	0.28	0.790
Aug. 6, 1875,		S. Walpole above all pollution, .	.0085	.0176	1.92	3.76	0.27	0.792
" 6, 1875,	c ²	Walpole at Bridge, .	.0052	.0171	2.76	5.04	0.38	1.165
" 6, 1875,	c ¹	Bridge above Ink Works, .	.0075	.0149	2.12	4.88	0.36	0.664
" 7, 1875,	C	Between S. Canton and Dedham, .	.0085	.0192	2.04	5.04	0.50	0.725
" 6, 1875,	B	Above junction with Mother Brook, .	.0080	.0197	1.92	5.04	0.51	0.684
" 6, 1875,	A	Milton Lower Mills above Baker's dam, .	.0123	.0160	2.16	5.56	0.48	0.668

- Cotton, Woolen and Silk Mills.
- * Saw and Grist
- ★ Machine Shops &c.
- △ Gas Works.
- Paper Mills.
- △ Tanneries.
- Dyeing, Bleaching & Curled Hair.
- ± Dams with head fall in feet.

Note

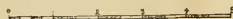
The figures indicate the available fall at each dam as of 1912. The letters will be found referred to in the tables of analyses and statistics.



NEPONSET RIVER.

Drainage Area 116. Sq. Miles.

Scale of Miles.



Taking in each case its head waters as the standard of purity for each particular valley, the above analysis, when compared with that standard, exhibits the effect of the trades-pollutions received as we follow down stream; but it cannot be said to show a degree of pollution here which would render the water unfit for general use, agreeing in this with the report of Mr. Ward, who states that "horses and cattle drink the water in all parts of the river." There are complaints, notwithstanding, reported from Walpole that the refuse fluids from mills and factories in that vicinity have killed the fish.

It is to be noted of the state of this river, as was remarked of the Blackstone, that the stream, although low, was not at its very low dry-weather stage, which occurs generally in October or November, but in some seasons not at all. In extreme low water the pollution received would be rendered more perceptible.

Of the waters of this valley, Prof. Nichols says: "The waters are all slightly alkaline, are somewhat colored, and deposit a slight sediment when allowed to stand quietly."

CHARLES RIVER.

The statistics of the Charles River Valley will now be presented, as they were taken this season by the assistant engineer, Mr. E. K. Clark. They are here given in the same tabular form as for the other rivers.

Mills, Factories, etc., in the Charles River Valley.

NAME OF RIVER OR STREAM.	Letters correspond- ing with Letters on Map.	DESCRIPTION OF MILL.	Location.	No. of Hands Em- ployed.	No. of Spindles.	Head and Fall.	Sets of machinery.	Quantities of Materials used per year, so far as known.
Charles River, .	A	Walker Pratt & Co., Foundry, ¹	Watertown, .	140	-	Ft. In. 4 6	-	Use some acid in pickling castings.
		Grist Mill, ¹	Watertown, .	3	-	4 6	-	3 run of stones.
		Paper Mill, ¹	Watertown, .	80	-	4 6	-	
		Ætna Wooden Mill, .	Watertown, .	250	-	4 2	12	300,000 lbs. material.
		Waltham Cotton Mills, ²	Waltham, .	626	-	12	-	
		Bleachery, ²	Waltham, .	213	-	-	-	At cotton and hosiery mills use 269,000 lbs. cotton.
		Hosiery Mill, ²	Waltham, .	351	-	-	-	
		Rice Paper Mill, ³	Newton L. Falls,	8	-	5 6	-	
		Shoddy Mill, ³	Newton L. Falls,	25	-	5 6	-	
		Dudley Hosiery Co., ³	Newton L. Falls,	50	-	6	-	48,000 lbs. cotton and wool.
		Rice Paper Mill, ⁴	Newton L. Falls,	18	-	8	-	Manufacture printing-paper.
		Cordingley's Woolen-Washing and Shoddy Mill, ⁴	Newton L. Falls,	10	-	15	-	
		Benj. Newell, Rolling Mill, ⁵	Newton U. Falls,	10	-	11	-	

Charles River, .	Paper Mill (not finished), ⁵	. . .	. . .	Newton U. Falls,	-	-	-	-	672,000 lbs. cotton.
	Newton Cotton Mills,	. . .	. . .	Newton U. Falls,	200	1,500	14	-	
B	(Above junction of Mother Brook.)								
	Paper Mill, ⁶	. . .	. . .	Charles Riv. Vill.,	14	-	9	2	
	Paper Mill, ⁶	. . .	. . .	Charles Riv. Vill.,	14	-	9	2	
	Grist Mill, ⁷	. . .	. . .	S. Natick,	-	-	7	-	Man'g leather board, use no rags.
	Paper Mill, ⁷	. . .	. . .	S. Natick,	15	-	7	-	
C	(At mouth of Harding Brook.)								
	Campbell's Paper Mill,	. . .	. . .	S. Natick,	7	-	4	-	
	Rockville Cotton Mill,	. . .	. . .	Medway,	35	1,500	7	-	
	Cotton-Bating Mill, Eaton & Wilson,	. . .	. . .	Medway,	15	-	6	-	660,000 lbs. cotton.
	Cotton-Bating Mill, Eaton & Wilson,	. . .	. . .	Medway,	15	-	11	-	330,000 lbs. cotton.
b	Medway Flock Co.,	. . .	. . .	Medway,	4	-	15	-	Washings from rags go into the water.
a	Campbell's Paper Mill,	. . .	. . .	Medway,	20	-	12	-	
	Careyville Woolen Mills,	. . .	. . .	Medway,	90	-	11	-	450,000 lbs. wool, 15,000 lbs. soda-ash.
c	Ray Woolen Mill,	. . .	. . .	N. Bellingham,	51	-	12	-	24,000 lbs. woolen material.
	Shoddy Mill, F. B. Ray & Co.,	. . .	. . .	Bellingham,	3	-	11	-	
	Grist and Saw Mill, J. B. Ray & Co.,	. . .	. . .	Bellingham,	-	-	10	-	
	Grist Mill,	. . .	. . .	Milford,	-	-	20	-	

¹ At one dam.² Belong to Boston Manufacturing Co.³ At one dam.⁴ At one dam.⁵ At one dam.⁶ At one dam, owned by one party.⁷ At one dam.

Mills, Factories, etc., in the Charles River Valley—Continued.

NAME OF RIVER OR STREAM.	Letters correspond- ing with Letters on Map.	DESCRIPTION OF MILL.	Location.	No. of Hands Em- ployed.	No. of Spindles.	Head and Fall.	Sets of Machinery.	Quantities of Materials used per year, so far as known.
Beaver Brook, .		Beaver Brook Netting Mills, . . .	Waltham, . .	40	1	16 Ft. In.	1	
		Silk Factory, ...	Waltham, . .	40	1	9 6	1	
Stony Brook, .		Roberts' Paper Mill, ...	Waltham, . .	12	1	16	1	1,500 tons stock.
		Stony Brook Machine Co., . . .	Waltham, . .	60	1	23	1	
		Hall's Shoddy Mill, ...	Waltham, . .	4	1	27	1	
		Saw Mill, ...	Waltham, . .	1	1	8	1	
Sibley Brook, .		Shattuck's Furniture M'f'y, . . .	Waltham, . .	4	1	27	1	
		Brown's Tool M'f'y, ...	Waltham, . .	2	1	21	1	
Hobos Brook, .		Grist Mill, ...	Waltham, . .	1	1	28	1	
Reservoir, .		Foundry and Machine-Shop, Pattee & Co.,	Newton U. Falls,	175	1	18	1	Pickle castings in acid.
Waban Brook, .	d	Wood's Paint Mill, ...	Natick, . .	22	1	13	1	
		Jenning's Saw Mill, ...	Natick, . .	1	1	13	1	
Savin's Brook, .		Saw and Grist Mill, ...	Natick, . .	1	1	15	1	
Ware Brook, .		Saw Mill, ...	Sherborn, . .	1	1	3	1	

Boggistere Br'k,

Collins' Saw Mill,	.	.	.	.	Sherborn,	.	-	2	8	-
Box Factory,	.	.	.	.	Medway,	.	-	3	5	-
Saw Mill,	.	.	.	.	Medway,	.	-	4	4	-
Stetson & Talbot, Nail M'f'y,	.	.	.	.	E. Holliston,	.	-	15	13	-
Payson's Saw & Box Factory,	.	.	.	.	E. Holliston,	.	-	5	10	-
(The Head Waters,)	.	.	.	.	E. Holliston.	.	-			
Thayer's Machine Shop,	.	.	.	.	Medway,	.	-	4	11	-
Box Factory,	.	.	.	.	Medway,	.	-	3	9	-
Saw and Grist Mill,	.	.	.	.	Medway,	.	-	-	9	-
Box Factory and Saw Mill,	.	.	.	.	Careyville,	.	-	-	10	-
Harding Saw Mill,	.	.	.	.	Medfield,	.	-	-	14	-
Saw Mill,	.	.	.	.	Medfield,	.	-	-	14	-
Cushman's Carriage Manufactory,	.	.	.	.	Medfield,	.	-	-	8	-
Cushman's Carriage Manufactory,	.	.	.	.	Medfield,	.	-	12	10	-
Campbell's Paper Mill,	.	.	.	.	Norfolk,	.	-	12	16	-
Ray Shoddy Mill,	.	.	.	.	Norfolk,	.	-	4	15	-
Franklin Woolen Man'g Co.,	.	.	.	.	Norfolk,	.	-	60	18	-
Shoddy Mill,	.	.	.	.	Norfolk,	.	-	2	4	-
Grist Mill,	.	.	.	.	Norfolk,	.	-	-	9	-
(The Head Waters,)	.	.	.	.	Norfolk.	.	-			

g

Chicken Brook,

Hopping Brook,

Harding Brook,

Medfield Brook,

Stop River,

Milk River,

i

Mills, Factories, etc., in the Charles River Valley—Concluded.

NAME OF RIVER OR STREAM.	Letters correspond- ing with Letters on Map.	DESCRIPTION OF MILL.	Location.	No. of Hands Em- ployed.	No. of Spindles.	Head and Fall.	Sets of Machinery.	Quantities of Materials used per year, so far as known.
Mine Brook, .		Daniels' Box Man'ry, .	Franklin, .	4	1	Ft. 8	1	300,000 lbs. wool; scour large amount of wool.
		Ray Felting Mill, .	Franklin, .	16	1	12	1	
		Shoddy Mill, .	Franklin, .	7	1	16	1	
		Felting Mill, J. B. Ray, .	Franklin, .	20	1	14	1	

Summary for Charles River Valley.

	Number.	Operatives Employed.
Woolen Mills, ...	14	336
Cotton Mills, ...	8	1,542
Paper Mills, ...	10	200
Iron Manufactories, ...	7	406
Paint Mills, ...	1	213
Saw Mills and Grist Mills, ...	1	40
Bleachery, ...	1	22
Silk Manufactories, ...	1	40
Total, ...	43	2,759

Additional Notes by Mr. Clark, Assistant Engineer.

"From Boston Harbor to Watertown, Charles River is a tidal stream. In this distance it receives a large amount of sewage from Boston, Cambridge, Somerville and other sources."

"*Watertown* (population 5,099) has no system of sewerage at present; surveys have been made with the intention of establishing a complete system of drainage which shall discharge into Charles River."

"*Waltham* (population 9,945) takes water from a reservoir near Charles River, at a point about one mile above the town. No system of sewerage has been perfected; in two or three of the main streets sewers have been built which empty into the river."

"*Newton* (population 16,105). The sewage from a part of the city goes into Charles River; cesspools are quite extensively used, the contents of which are removed once or twice during the year. Water-works are in process of construction; water is to be taken from a reservoir near Charles River a little above Newton Upper Falls."

"*Dedham* (population 5,756) has no water-supply or sewerage system; proposes taking water from a reservoir to be built near Charles River. A portion of Dedham drains into Neponset River through Mother Brook."

"*Needham* (population 4,536), *Dover* (population 650), and a part of *Natick* (population 7,419) drain indirectly into the river. Much of the sewage of *Natick* finds its way into Cochituate Lake, although the town has not yet sewers. Along the river from Boston to *Natick* the soil is favorable for the utilization of sewage, although it might be necessary to pump it to get sufficient area. The country, located as it is, near Boston, and possessing many natural advantages, makes it desirable as a place of residence; and it is being rapidly taken for this purpose. The value of the land is increasing from year to year, and at the same time the amount of sewage discharged into the water along this part of the river is increasing. The opinion has been given that the river below *Natick* should be regarded as a sewer, and walled in; while above this point the water should be kept as free from pollution as possible, with the intention of using the upper water in the towns. All the towns above *Natick* discharge more or less sewage directly into the river."

"*Medway* (population 4,237) is situated almost wholly on the river, and drains into it."

"*Holliston* (population 3,339) is so situated that the sewage from a large part of the town must flow directly into the river."

"*Milford* (population 9,818) is a town of considerable importance; has no water-supply or system of sewerage. In the principal street a sewer has been built which empties into Charles River. The surface-drainage is quite effectual, and flows directly into the river over the meadows, which have increased in value from the larger crops of grass they produce than formerly. A small amount of refuse escapes into the river from the gas-works. Before the mills on the lower part of the river were built, pickerel and trout were quite abundant; now there are comparatively few. The soil about *Milford* is a sandy loam, and the sewage could without difficulty be conveyed upon some of the low land in the neighborhood."

"The rock about the upper waters of the Charles River is

granite. It has been proposed to divert the sewage of Milford from the Charles River into the Blackstone. The land about the head of the Charles River is gradual in its ascents; the rock is almost wholly granite. The valley is entirely free from limestone. The water of the Charles is tolerably clear, and light brown in color, with the exception of the two cases before mentioned,—Cedar Swamp Pond, whose water does not seem to be very clear, and the water of Boggistere Brook, in Holliston, which is a little darker in color, but still transparent.”

“The Brighton abattoir is situated upon tide-water of the Charles River. At this establishment there are killed about 1,700 head of cattle and 6,000 sheep per week. Most of the refuse is saved and manufactured into tallow, oil, fertilizer, glue, etc. The water in which a part of the refuse is boiled is afterwards evaporated for the glue, during the cool weather. The water used about the works is drawn from wells; there are used on an average per day, about 50,000 gallons, three-fourths of which, at least, must be used for washing purposes. This latter, as it runs from the floors, goes into a sewer, thence into the river, and is almost the whole and only kind of refuse that gets into the river. The works are neat, and are conducted so that there is the least possible waste.”

“The rendering establishments above here are closed permanently.”

ANALYSIS OF STATISTICS.

In the following two tables will be found the statistics indicating the condition of the water at certain points in the Charles River Valley, for comparison with the analyses of that water at the same points, and also from the head waters of the valley.

CHARLES RIVER VALLEY.—This table is intended to explain the summer flow of the stream, and the amount of its previous exposure, at certain of the points whence water was taken for analysis. The points are indicated by the same letters on the map, and on the table of analyses.

SEE THE POSITIONS OF THESE LETTERS ON THE MAP, ...						
	A	e	B f	C	K	a
Drainage-area above points indicated, square miles, ...	295.8	236.9	219.8	156.3	94	69.8
The same, deducting one-third for points below Mother Brook, square miles, ...	197.2	158	-	-	-	-
Dry-weather flow at respective points in 24 hours, cubic feet, ...	3,407,616	2,730,240	3,798,144	2,700,864	1,624,320	1,206,144
" " " " U. S. gallons, ...	25,488,967	20,422,195	28,410,117	20,202,462	12,149,913	9,021,957
Number of polluting factories or mills, ...	43	23	22	17	13	8
" " " " per square mile, ...	0.12	0.09	0.1	0.11	0.14	0.11
Number of operatives in said mills, ...	2,759	620	445	365	307	211
Population in basin above respective points, 1855, ...	44,510	28,714	24,975	16,697	12,987	10,204
" " " " 1870, ...	62,605	39,184	32,573	21,982	18,033	13,000
" " " " 1875, ...	71,153	43,781	35,469	25,389	21,129	13,400
" " " " 1875, per square mile, ...	273.8	184.8	161.3	162.4	224.7	192
Population of cities, villages and mills sewerage into the river above the points indicated, 1875, ...	21,511	13,887	12,205	8,278	6,513	4,971
Population of this character per square mile, ...	72.7	58.6	55.5	52.9	69.3	71.2

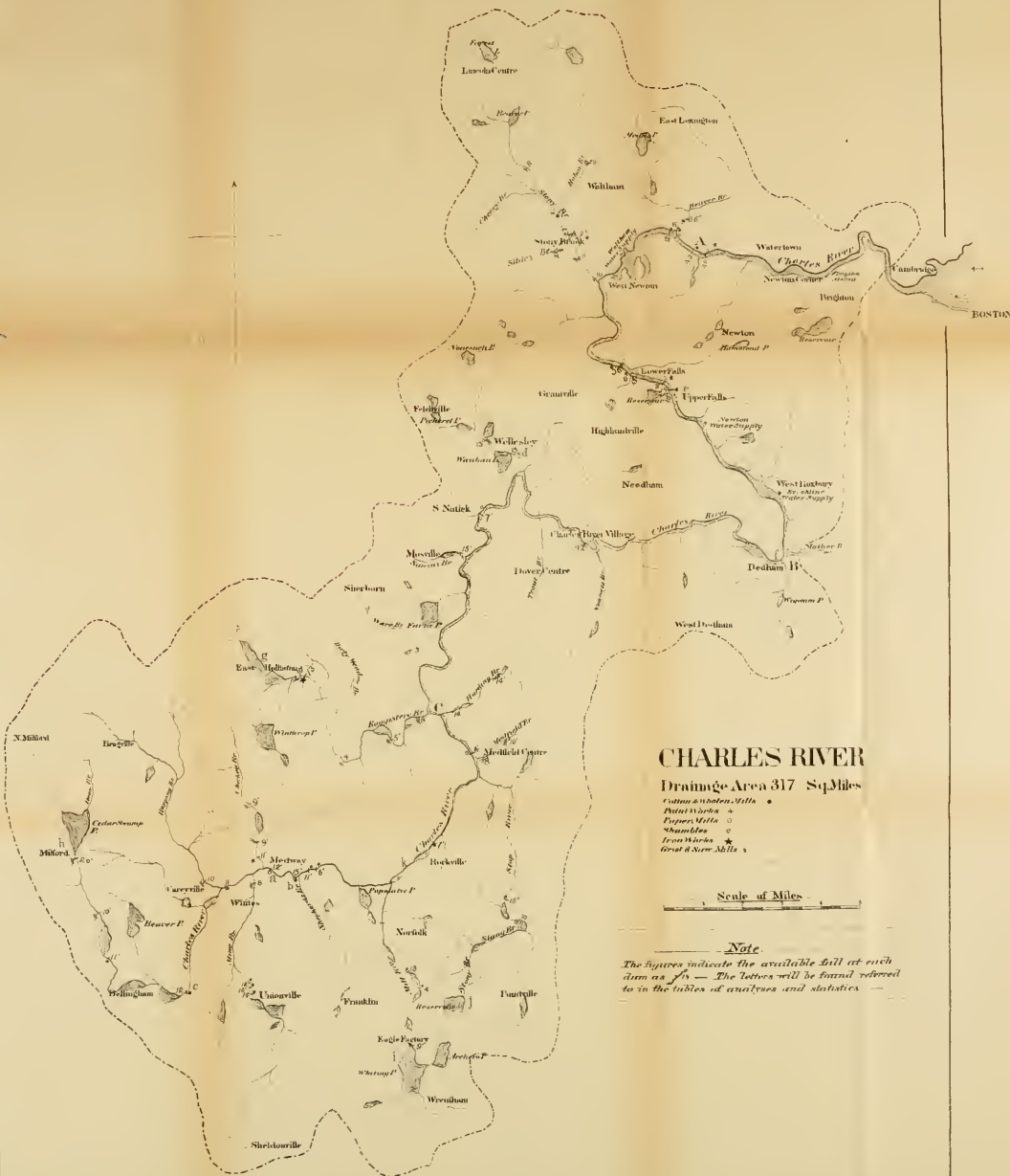
Analysis of the Waters of the Charles River.

[Parts per 100,000.]

DATE.	Letters on Map.	LOCALITY.	Ammonia.	"Albuminoid Ammonia."	SOLID RESIDUE.		Chlorine.	Oxygen required.
					Organic.	Total.		
Oct. 1, 1875,	g	East Holliston Pond above all pollution, .	.0083	.0208	1.48	3.92	0.36	-
" 1, 1875,	i	Whiting Pond above all pollution, .	.0059	.0107	0.84	3.00	0.28	-
Aug. 31, 1875,	a	Charles River, Medway, .	.0128	.0229	2.32	5.04	0.40	0.635
Oct. 1, 1875,	K	Charles River below Mill River, .	.0069	.0187	1.48	4.64	0.48	-
Aug. 24, 1875,	C	Charles River below Bellingham, .	.0059	.0299	3.00	6.20	0.35	0.990
" 31, 1875,	B f	Charles River, Dedham, .	.0096	.0328	2.72	5.40	0.36	0.868
" 31, 1875,	e	Charles River above Newton Lower Falls, .	.0080	.0293	2.92	5.60	0.40	1.043

From this table it can hardly be asserted that the Charles River water above Newton Lower Falls, if properly filtered, is unfit for domestic use, and yet the river has received the polluting refuse of forty-two mills and factories, and is in that respect very much in the same condition as the Thames above London, having, however, a greater population per square mile than the Thames basin. The country seems destined to fill up fast on the lower portions of this basin convenient to Boston, and the prospect, therefore, of a large addition to the sewage-pollution of the stream is certain within the next ten years, unless, in the meantime, some mode of meeting and controlling the evil is made applicable.

The most of the samples of water analyzed in this table were taken from the river late in August at a low summer stage of the stream; but they cannot be said to have been taken during its lowest dry-weather stage which usually occurs later, and in that case would have shown more distinctly the contaminations received. This low dry-weather stage following a season of low rainfall, does not occur every season, and has not thus far (November) occurred this year. The samples analyzed give probably a fair view of the character of the water during its usual summer stage.



CHICOPEE RIVER.

The river-statistics of the Chicopee Valley will now be given as they were gathered this season by the assistant engineer, Mr. Charles D. Ward. This is the largest river-basin within the State, comprising an area of seven hundred and eighteen square miles, of which two hundred and eighty-six square miles remain at this date uncontaminated by any polluting refuse other than what may proceed from farming operations and a very scattered population. There is no trades-pollution on this portion, nor any concentrated sewage.

To the tabular statement here given (see pp. 110–118), Mr. Ward adds the following notes:—

In the large district, above point C on the map, “the sewage is a very small matter, as there are no large towns.”

“At West Warren, seventy tenements, perhaps five or six persons in each, are connected with the river by drains, but simply sink and surface water enter them, as the water-closets do not connect.

“Nearly all the water-closets of the factories and mills, employing 2,340 hands, in those visited and noted, empty directly into the river.

“*Minerals, etc.*—This whole division seems to be composed of igneous rocks.

“There is iron scattered through a large part, especially a few miles south of North Dana, where an old abandoned mine is shown, and another a few miles north-east of Gilbertville.

“There are also strong iron-springs at Coldbrook, and near West Warren, which are used medicinally.

“The hills are from two hundred to five hundred feet in height.”

Between B and C on the Map.

“*Sewage.*—At Three Rivers there are a few drains that take sink-water from about three hundred persons, but very few water-closets connect: at Bond’s Village, or Duckville, about one hundred and fifty, under same conditions. At Thorn-dike, thirteen tenements; about five in each are drained, but no water-closets.

Mills, Factories, etc., in the Chicopee Valley.

NAME OF STEAM OR BRANCH.	Letters correspond- ing with Letters on Map.	DESCRIPTION OF MILL, Etc.	Location.	No. of Hands Em- ployed.	No. of Spindles.	Head and Fall.	Sets of Machinery.	Quantities of Materials used per year, so far as known.
Chicopee River, .	A a ¹	Byrrt & Bullens, Tanners, etc., .	Chicopee, .	7	-	Feet. -	-	5,000 hides tanned a year.
		E. Wood & Son, Saw and Grist Mill,	Chicopee, .	-	-	7	-	Two run of stones.
		Dwight M'f'g Co., Cotton Mills, .	Chicopee, .	1,500	110,000	30	-	4,000,000 cub. feet gas.
		Dwight M'f'g Co., Gas Works, .	Chicopee, .	-	-	-	-	Ten tons oil of vitriol.
		Ames M'f'g Co., Iron and Brass W'ks,	Chicopee, .	300	-	-	-	Four tons oil of vitriol.
		Gaylord M'f'g Co., Lock Factory, .	Chicopee, .	60	-	8	-	390 tons coal estimated to make 3,250,000 cub. feet gas.
		Chicopee Man'f'g Co., Cotton Mills,	Chicopee Falls, .	1,200	62,100	-	26	One ton oil of vitriol.
		Chicopee Man'f'g Co., Gas Works, .	Chicopee Falls, .	-	-	-	-	Four and a half tons oil of vitriol.
		Lamb Knitting-Machine M'f'g Co., .	Chicopee Falls, .	60	-	8	-	75 tons oil of vitriol, 54 tons chl. lime, 9 tons soda-ash, 50 bbis. lime.
		Bay State Dye and Alpaca W. W'ks,	Chicopee Falls, .	6	-	7	-	Two run of stones.
		Belcher & Taylor, Agricultural Tools,	Chicopee Falls, .	60	-	16	-	
Branch of Chicopee R.,		Hampden Bleaching Co., ...	Chicopee Falls, .	20	-	-	-	
Chicopee River, .		J. Stevens & Co., Pistol Factory, .	Chicopee Falls, .	35	-	6	-	
		J. Stevens & Co., Grist Mill, . .	Chicopee Falls, .	-	-	-	-	

Chicopee River, .	B. & J. W. Belcher Agricult ^l Tools	Chicopee Falls, .	40	-	11	-	One-sixth of a ton of oil of vitriol.
Higher Brook, .	Eaton's Batten Mill, .	Higher Brook, .	9	-	15	-	One run of stones.
Chicopee River, .	Eaton's Grist Mill, .	Higher Brook, .	-	-	-	-	180 tons coal, estimated to make 1,500,000 cub. feet gas.
	Indian Orchard Cotton Mill, .	Indian Orchard, .	650	60,000	33	-	Two tons soda-ash, 2 tons sal-soda and 12 tons bleaching-powder.
	Indian Orchard Gas Works, .	Indian Orchard, .	-	-	30	-	3,800 bbls. common lime, 4,050 tons bleaching-powder and 120 carboys muriatic acid.
	Ludlow M ^r 'g Co., Cotton, Linen, etc.,	Ludlow, .	-	-	12	-	
	Ludlow M ^r 'g Co., Cotton, Linen, .	Ludlow, .	325	-	14	-	
	Collins Paper Co., Fine Book-Paper,	Ludlow, .	250	-	20	2	
Twelve Mile Brook, .	E. W. Ellis & Bro., Woolen Mill, .	Twelve Mile Brook, .	40	-	20	1	
Chicopee River, .	Silver Street Mill, Horse Blankets, .	Twelve Mile Brook, .	10	23,000	14	-	200,000 cub. feet gas, estimated.
	Palmer Cotton Mill, .	Three Rivers, .	400	-	-	-	Make No. 2 printing-paper.
Swift River, .	Palmer Cotton Mill, Gas Works, .	Three Rivers, .	-	-	12	-	One run of stones.
	Potter's Saw Mill, .	Bond's Village, .	-	-	14	-	
	Geo. Fowler's Paper Mill, .	Bond's Village, .	12	-	10	-	
	Bond & Fosdick, Grist Mill, .	Bond's Village, .	-	-	20	-	125,000 cub. feet gas, estimated.
	Boston Duck Co., Cotton Mill, .	Bond's Village, .	250	15,000	10	-	Not running.
	Boston Duck Co., Gas Works, .	Bond's Village, .	-	-	-	-	
	John Warren, Shoddy Mill, .	Below Enfield, .	8	-	13	-	
Ware River, .	Thorndike Co., Cotton Mill, .	Thorndike, .	150	12,032	-	-	

^{sc} B

Mills, Factories, etc., in the Chicopee Valley—Continued.

NAME OF STREAM OR BRANCH.	Letters correspond- ing with Letters on Map.	DESCRIPTION OF MILL, ETC.	Location.	No. of Hands Em- ployed.	No. of Spindles.	Head and Fall. Feet.	Sets of Machinery.	Quantities of Materials used per year, so far as known.
Ware River,	C	Thorndike Co., Cotton Mill, . .	Thorndike, . .	360	14,064	18	—	
		Gilbert M'f'g Co., Woolen Mill, .	Ware, . .	250	—	5½	7	
		C. A. Stevens & Co., Woolen Mill, .	Ware, . .	175	—	18	10	
		Otis & Co., Cotton Mill, . .	Ware, . .	300	8,448	16	—	
		Otis & Co., Cotton Mill, . .	Ware, . .	150	7,872	17	—	
		Otis & Co., Cotton Mill, . .	Ware, . .	180	8,896	26	—	
		Otis & Co., Gas Works, . .	Ware, . .	—	—	—	—	240 tons coal, estimated to produce 2,000,000 cub. feet gas.
Branch,	B	J. Beche & Son, Woolen Mill, . .	Monson, . .	60	—	12	5	
		Harrison Day, Saw and Grist Mill, .	Monson, . .	—	—	8	—	
		Merrick, Fay & Co., Straw Hat W'ks,	Monson, . .	325	—	—	—	Two run of stones.
		Lyons Woolen Mill, . .	Monson, . .	50	—	12	4	30 tons soda, 50 bbls. brimstone, 2,000 lbs. sugar of lead, 2,000 lbs. oxalic acid, 6,000 lbs. dyerwood, 500 lbs. bichromate of potash and 500 lbs. copperas.
		J. L. Reynolds' Woolen Mill, . .	Monson, . .	40	—	17	3	

Branch, . . .	J. L. Reynolds' Woolen Mill, not finished.	Monson, . . .	65	-	15	5
	D. W. Ellis, Woolen Mill, . . .	Monson, . . .	55	-	22	4
	West Branch, . . .	Monson, . . .	30	-	22	2
	Palmer Carpet Co., . . .	Palmer, . . .	60	-	-	16
Quaboag River, . . .	A. V. Blanchard, Harness Factory, . . .	Palmer, . . .	-	-	4	-
	A. V. Blanchard, Scythe Factory, . . .	Palmer, . . .	-	-	6	-
	A. V. Blanchard, Saw Mill, . . .	Palmer, . . .	-	-	8	-
	A. V. Blanchard, Grist and Plaster Mill.	Palmer, . . .	2	-	8	-
	² C					
Swift River, . . .	Minot M'f'g Co., Woolen Mill, . . .	Enfield, . . .	50	-	12	5
	Minot M'f'g Co., Grist Mill, . . .	Enfield, . . .	-	-	12	-
	Swift River Co., Woolen Mill, . . .	Enfield, . . .	85	-	16	8
	Swift River Co., Grist and Saw Mill, . . .	Enfield, . . .	-	-	16	-
Middle Branch, . . .	Harrison Barrows' Saw Mill, . . .	N. Dana, . . .	-	-	7	-
	Hale, Goodman & Co., Piano Legs, . . .	N. Dana, . . .	25	-	8	-
	^{d3}					
Ware River, . . .	Gilbert's Saw and Grist Mill, . . .	Gilbertville, . . .	-	-	16	-
	Geo. H. Gilbert, Woolen Mill, . . .	Gilbertville, . . .	300	-	20	17
	Geo. H. Gilbert, Woolen Mill, . . .	Gilbertville, . . .	200	-	22	11
	¹ C					
						Three run of stones.

Mills, Factories, etc., in the Chicopee Valley—Continued.

NAME OF STREAM OR BRANCH.	Letters correspond- ing with Letters on Map.	DESCRIPTION OF MILL, ETC.	Location.	No. of Hands Em- ployed.	No. of Spindles.	Head and Fall.	Sets of Machinery.	Quantities of Materials used per year, so far as known.
Ware River, . . .	.	Page Paper Co., . . .	Hardwick, . . .	40	-	Feet. 9	-	320 bbls. common lime, 80 tons alum, 60 tons bleaching-powders; make news-paper.
		Holden's Saw and Grist Mill, . . .	Barre, . . .	-	-	10	-	Two run of stones.
		Dennyville Woolen Mill, . . .	Barre, . . .	75	-	8½	4	
		American Powder Co., . . .	Barre, . . .	-	-	14	-	Given up.
		Smithville Cotton Mill, . . .	Barre, . . .	80	4,500	19	-	
Cold Brook, . . .	.	Whiting's Machine-shop, . . .	Coldbrook, . . .	15	-	13	-	
		Matthews' Agricultural Tools, . . .	Coldbrook, . . .	6	-	6	-	
Natty Pond Brook, . . .	.	John Woodard's Tannery, . . .	Hubbardston, . . .	2	-	8	-	500 hides and calf-skins.
Burn Shirt River, . . .	.	Howard's Saw Mill, . . .	Barre, . . .	-	-	10	-	
		Holland's Saw Mill, . . .	Barre, . . .	-	-	10	-	
		Williams & Browning Chair Factory, . . .	Williamsville, . . .	20	-	12½	-	
		S. P. Hale, Saw Mill, . . .	Williamsville, . . .	-	-	16	-	
		E. R. Brown, Saw Mill, . . .	East Phillipston, . . .	-	-	10	-	
		Mrs. W. Leland, Saw Mill, . . .	East Phillipston, . . .	-	-	11	-	

Burn Shirt River,	Soap Factory (burned down), .	East Phillipston,	.	-	-	16	-
	J. W. Wilkinson, Machine-shop,	East Phillipston,	.	1	-	24	-
	Fay's Saw Mill,	East Phillipston,	.	6	-	20	-
	Chase & Lamb, Wooden Box Factory,	East Phillipston,	.	2	-	10	-
Wine Brook,	P. M. Sanderson, Tannery,	East Phillipston,	.	-	-	9	-
	J. D. Parker & Co., Chair Factory,	East Phillipston,	.	15	-	27	-
Burn Shirt Brook,	L. Whitney, Chair Factory,	East Phillipston,	.	9	-	30	-
	O. Mixter, Chair Factory,	East Phillipston,	.	14	-	18	-
	Conant's Grist Mill,	Barre,	.	-	-	9	-
Prince River,	Jason, Desper & Co., Hat Finisher,	Barre,	.	50	-	12	-
	Heald & Co.,	Barre,	.	30	-	16	-
	Two run of stones.						
	Quarter of a ton of oil of vitriol.						
	27,000 lbs. bleaching-powder, 97,500 lbs. dyewoods, 19,000 lbs. bichromate of potash, 88,000 lbs. cutch.						
	36,011 gals. of oil, making 266,700 c. ft. gas.						
Quaboag River,	West Warren Tool Manufactory,	West Warren,	.	40	-	12½	-
	Warren Cotton Mills,	West Warren,	.	250	10,000	15	-
	Warren Cotton Mills,	West Warren,	.	125	5,500	16	-
	Warren Cotton Mills,	West Warren,	.	200	7,500	16	-
	Warren Cotton Mills, Gas Works,	West Warren,	.	-	-	-	-
	G. E. Keeney, Shoddy and Flocks,	West Warren,	.	10	-	12	-
	Warren Woolen Mill,	Warren,	.	130	-	12	8
	W. B. Ramsdell, Boot Factory,	Warren,	.	20	-	-	-

Mills, Factories, etc., in the *Chicopee Valley*—Concluded.

NAME OF STREAM OR BRANCH.	Letters corresponding with Letters on Map.	DESCRIPTION OF MILL, ETC.	Location.	No. of Hands Employed.	No. of Spindles.	Head and Fall.	Sets of Machinery.	Quantities of Materials used per year, so far as known.
Quabog River, .	C ¹ & C ²	B. A. Tripp, Boot Factory, .	Warren, .	60	1	Feet. —	1	Steam-pump manufactory.
Branch, . . .		L. J. Knowles, Pump Works, .	Warren, .	150	—	18	—	
Quabog River, .		L. J. Knowles, Cotton Warp, .	Warren, .	22	1,200	6	1	
		Gould's Plaster and Grist Mill, .	Warren, .	—	—	6	—	Three run of stones.
East Brookfield River,		Saw and Grist Mill, . . .	East Brookfield, .	—	—	—	—	Two run of stones.
		Foundry, ...	East Brookfield, .	12	—	—	—	
		Brookfield Cotton Mill, . .	East Brookfield, .	75	3,200	15	—	
Seven Mile River, .		Forbes & Fay, Wheel Factory, .	East Brookfield, .	10	—	17	—	
		Westville Woolen Mill, . .	Spencer, .	30	—	10	2	
Branch, . . .		Livemore's Box Factory, .	Spencer, .	8	—	24	—	
		Beemer's Saw and Grist Mill, .	Spencer, .	3	—	18	—	One run of stones.
		Spencer Woolen Mill, . . .	Spencer, .	40	—	30	2	
		Spencer Woolen Mill, . . .	Spencer, .	40	—	22	2	
		Spencer Woolen Mill, . . .	Spencer, .	40	—	23	2	

Branch,	James Capin, Grist Mill,	Spencer,	27	One run of stones.
	Watson's Wood Planing Mill,	Spencer,	1½	
Seven Mile River,	Samuel Barnes & Co., Planing Mill,	Spencer,	7	
	Proutey's Wire Mill,	Wire Village,	21	13½ tons of oil of vitriol.
Turkey Hill Brook,	Proutey's Wire Mill,	Wire Village,	26	4½ tons of oil of vitriol.
	Sugden's Saw Mill,	Wire Village,	10½	
	Sugden's Wire Mill,	Wire Village,	28	18 tons of oil of vitriol.
	Sugden's Wire Mill,	Wire Village,	14	} Nine tons of oil of vitriol.
Shaw Brook,	Sugden's Wire Mill,	Wire Village,	30	

Summary.

	Number.	Operatives Employed.
Cotton Mills, ...	18	6,228
Foundries and Machine-shops, ...	33	1,102
Woolen Mills and Dye Works, ...	26	1,028
Bleaching Works, ...	1	20
Paper Mills, ...	3	262
Hat Works, ...	1	325
Tanneries, ...	3	19
Gas Works, ...	6	—
Saw and Grist Mills, ...	34	—
	125	8,984

"At Ware, one hundred and fifteen tenements discharge sink and surface water only into the river.

"The whole district seems to be of igneous formation, with hills from two hundred to five hundred feet high."

Between the mouth of the River and B on the Map.

"*Sewerage.*—Chicopee, the largest village in the valley (population about 5,000), has a plan for sewerage the whole village, made by W. B. Harris, in 1873; but no sewers have as yet been built under it. It proposes emptying all of the sewage into the Connecticut River, near the bridge. At present there are about four thousand feet of old sewers that empty into the Dwight Manufacturing Company's race-way, and about the same length of sewer and brook used for sewer, that empty into this tail-race only a few feet from the Connecticut River. Very few houses connect with these sewers; they are for surface-waters mainly.

"On the north side of the Chicopee River, the opposite side from the village, and between the Connecticut River Railroad and the Connecticut River, there is a piece of sandy, loamy ground, perhaps two miles long by one mile wide, on which most of the sewage from the village could be deposited by gravity, and used for irrigation.

"Chicopee Falls, with a population of say 4,000, has drains through three-fourths of the village. There is no good ground for irrigation accessible, except some river-flats below the village, that are covered with water in every little freshet.

"Indian Orchard, with a population of about 1,800, is quite completely sewerage, and nearly all the water-closets connect.

"Half a mile below the village there is very good ground for irrigation, said to be one mile long by one-third of a mile wide, and to be twenty feet above the river there, and at the same time thirty feet below the level of the village.

"The rocks in this division are mostly sandstone, with hills not much over one hundred feet above the streams.

"Water is not taken by any village from the river for domestic use, that I found, but some of the villages have a partial supply from springs on the hillsides.

"At Page's paper-mill, on the Ware River, water from the

river is used in the manufacture of news-paper, but it is said not to be pure enough for fine paper, on account of the iron in it.

"*Fish*.—Pickerel, perch, dace, suckers, shiners, and sunfish are caught in all parts of the river. No fish seem to have abandoned the river, but the number is reduced by being caught out. Horses and cattle drink the water in all parts of the river freely.

"At Chicopee, the upper dam, with a head and fall of thirty feet, includes the two lower ones of eight and seven feet, as they merely get what flows over the upper one. The same is true of the twenty-six-feet dam at Chicopee Falls."

ANALYSIS OF STATISTICS.

In the following table will be found summarized the river-statistics of some of the points from which samples of water were taken for the chemist, from which the extent of the previous pollution can be judged of and compared with its exhibition in the proper analysis.

I will give, too, from the tables of analyses, the results for the points indicated in the table just mentioned, and those also of some of the head waters of this river, for comparison :—

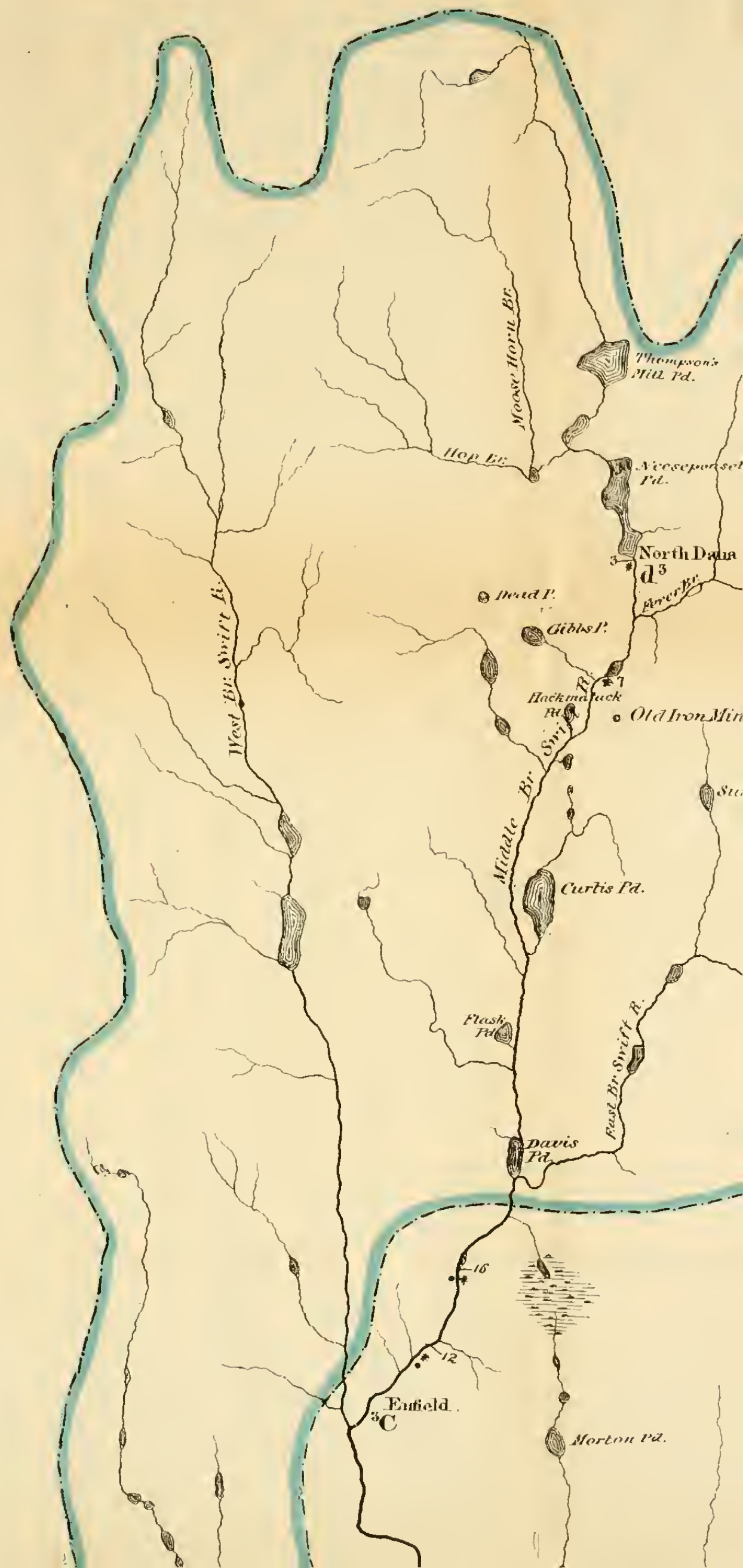
Summary of Statistics for certain points on the Chicopee Valley.

SEE THESE LETTERS ON THE MAP, ...	A	B	³ C	¹ C	² C	d ³	d ¹	d ²
Drainage-area in square miles above the point indicated, .	718.74	642.18	134.69	163.12	140.78	26.25	57.81	9.22
Dry-weather flow at respective points in 24 hours, cub. feet,	12,419,827	11,096,870	2,327,443	2,818,714	2,432,678	453,600	998,956	159,321
The same in U. S. gallons, ...	92,900,305	83,004,587	17,409,273	21,083,980	18,196,431	3,392,923	7,472,190	1,191,721
Number of polluting factories, works or mills (including saw and grist mills),	.72	.56	.2	.12	.20	-	-	-
Number of polluting factories, etc., per square mile, . . .	.10	.09	.01	.07	.14	-	-	-
Number of operatives in said factories, ...	7,881	5,176	135	801	1,220	-	-	-
Population on basin above respective points in 1875, . .	55,015	44,873	4,549	6,964	18,000	1,110	1,659	455
Population on basin above respective points per square mile,	76.54	69.88	33.77	42.69	127.86	42.28	28.70	49.35
Population of cities, villages, mills or works sewerage into the river now above said points.	14,415	6,910	166	881	1,751	-	-	-
Population of this character per square mile, ...	20.06	10.76	1.23	5.40	12.44	-	-	-

- Cotton & Woolen Mills
- * Saw & Grist
- ★ Machine Shops, Wire " & c.
- ▲ Gas Works
- Paper Mills
- △ Tanneries
- Dyeing & Bleaching
- H Boot Factories
- 12' Dams with Head & Fall in feet

Note

The upper portions of the basin shaded blue, include the greater part of the waters, which are not exposed to Sewage pollution now; nor to pollution from Factories. The few Grist Mills & Saw Mills within the ground not being considered polluting elements in the same sense as the others. These uncontaminated Waters drain 286 Square Miles. None of these Waters however could be withdrawn for City use without compensation to the Mill Owners affected below.





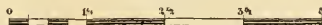




CHICOPEE RIVER

Drainage Area - 718 $\frac{71}{100}$ Sq. Miles

Scale of Miles



Note

*The figures indicate the available
fall at each dam as $\frac{1}{2}$ ft.
The letters will be found referred
to in the tables of analyses and
Statistics*

Analysis of the Waters of the Chicopee River.

[Parts per 100,000.]

DATE.	Letter on Map.	LOCALITY.	Ammonia.	"Albuminoid" Ammonia.	SOLID RESIDUE.		Chlorine.	Oxygen required.
					Organic.	Total.		
Aug. 9, 1875,	d ¹	Ware River, near Barre Falls, no pollution, ...	.0075	.0227	2.96	5.72	0.16	1.606
" 7, 1875,	d ²	Turkey Hill Brook, above pollution, ...	.0123	.0171	3.20	5.08	0.16	1.373
July 22, 1875,	d ³	Swift River, above pollution, ...	.0053	.0128	1.88	3.52	0.08	0.432
Aug. 9, 1875,	C ¹	Ware River, below Gilbertville, ...	.0069	.0181	2.56	4.48	0.15	1.062
" 7, 1875,	C ²	Quabog River, below West Warren, ...	.0059	.0107	1.88	4.44	0.17	0.564
July 22, 1875,	C ³	Swift River, below Enfield, ...	.0093	.0165	2.16	4.44	0.09	0.536
" 22, 1875,	B	Chicopee River, near Three Rivers, ...	.0064	.0115	2.32	4.80	0.11	0.508
" 10, 1875,	A	Chicopee River, at Dwight Dam, ...	.0112	.0155	2.08	5.08	0.12	0.498
" 21, 1875,		Connecticut River, immediately above Springfield, ...	.0085	.0139	1.68	6.12	0.09	0.393

On this river, although there are seventy-two mills and factories in the valley, each of a character to throw some polluting refuse into the neighboring stream, we see that analysis gives no evidence of the waters being thereby damaged. This must be due to the fact that a large portion of the water-power of this valley remains still unoccupied by mills or factories. In the main stream one-third of the water at least has not been exposed to any kind of trades-pollution. It will also be due in part to the fact that the streams were not at their lowest stage when the samples of water were taken. On the Chicopee Valley, however, under any circumstances, the waters are in sufficient abundance to dilute, much more than on the other streams examined, any impurities received by them, and consequently are to this extent in a safer condition now for common use.

Of the Chicopee waters, Prof. Nichols says :—

“All the specimens of water from the Chicopee Valley were somewhat alkaline, and no case was observed where any refuse of an acid character had been thrown into the streams in sufficient quantity to alter the alkaline character of the water.

“All the specimens were more or less colored by vegetable matter in solution. All deposited, on standing, a slight sediment containing vegetable matter, partly in combination with iron. There was not enough sediment in any case to make its determination seem of any practical moment.

“The samples from the Connecticut River (Nos. 11 and 12) were less strongly colored, and produced a more marked alkaline reaction. They contained a larger proportion of mineral matter, as appears from the table.”

TAUNTON RIVER.

The statistics of the Taunton River Valley come next in order. This is the last of the five rivers examined this season. The information concerning it was collected by Mr. Frank L. Fuller, assistant engineer.

River-Statistics, Mills, Factories, etc., of the Taunton Valley.

NAME OF STREAM OR BRANCH.	Letters corresponding with Letters on Map.	DESCRIPTION OF MILL, ETC.	Location.	No. of Hands Employed.	Splindles.	Head and Fall.	Quantities of Materials used per year, so far as known.
Three Mile River, .	b	Dighton Furnace Co., ...	Taunton, ...	100	-	Feet. } 7 }	1,500 tons iron, 700 tons coal.
		Dighton Pipe Works, ...	Taunton, ...	55	-		1,800 tons iron, 1 carboy sulphuric acid.
		Lincoln's Paper Mill, ...	Dighton, ...	17	-	8	386 tons paper made in 1874; 2 carboys sulph. acid, manilla and coarse packing; 3 casks bleaching-powder.
		Mount Hope Thread Mill, ...	Dighton, ...	42	-	-	93,600 lbs. cotton thread and yarn made per year.
		Westville Cotton Factory, ...	Taunton, ...	72	5,436	12	624,000 lbs. cotton thread and yarn made per year.
		Oakland Cotton Factory (A. F. Howard & Son), ...	Taunton, ...	84	3,724	8	249,600 lbs. cotton made into cloth, blue and brown; 5,840 lbs. indigo, 30,000 lbs. crech, 1,400 lbs. blue vitriol, 1,100 lbs. ext. logwood, 5,400 lbs. potash, 200 lbs. flour, 250 gals. molasses.
		Birch Brook, ... Rumford River, ...	c	Saw Mill, ...	Norton, ...	-	-
Saw Mill, ...	Norton, ...			12	-	8	
Batten and Saw Mill (L. Willis), ...	Norton, ...			-	-	7	
Norton Wool Scouring Mills (F. A. Story & Co.), ...	Norton, ...			12	-	8	1,200,000 lbs. wool cleaned; 2,000 lbs. soda-ash, 2 bbls. red oil. Some wool contains 75 p. ct. of dirt and grease; this is all turned into the stream.
		Saw Mill, ...	Norton, ...	-	-	-	

Rumford River, .	Saw Mill, ...	-	-	-	-	-	Imitation rubber, gold and plated jewelry ; use 10 carboys sulphuric and nitric acids.
	Saw and Grist Mill (Fisher Bros.), .	-	-	-	-	11	
	Jewelry Factory (F. W. Cabot), . .	-	-	-	-	12	
	Jewelry Factory (Kingman & Hodges),	-	75	-	-	14	
	Knife Works (Robert Fulton), . .	-	-	-	-	5	12,480 doz. shoe-knives, 6,240 gross awls.
	Knife Works (J & R. Murphy), . .	-	-	-	-	12	Not in operation at present (Sept., 1875).
	Gardner Chilson's Stove and Furnace Foundry.	-	-	-	-	Steam.	1,000 tons iron made into stoves, etc.; 10 carboys sulphuric acid.
	Mansfield Spindle Works, ...	-	-	-	-	Steam.	48,000 spindles made; use $7\frac{1}{2}$ tons steel, 12 tons cast-iron, $4\frac{1}{4}$ tons composition.
	Grist Mill (McAvoys), ...	-	-	-	-	7	Runs all the year.
Billings Brook, .	Shingle Mill, ...	-	-	-	-	12	
	Shingle Mill, ...	-	-	-	-	21	Use 25 carboys sulph. acid, 5 carboys nitric acid.
Wading River, .	Copper Works, Crocker, Bros. & Co., .	-	-	-	-	6	Run $3\frac{1}{2}$ months per year.
Goose Brook, . .	Shingle Mill (G. H. Arnold), . . .	-	-	-	-	-	
	Shingle and Box B'd Mill (A. D. Lane),	-	-	-	-	12	218,400 lbs. cotton made into white drill- ings.
Wading River, .	Cotton Mill (Wheaton's), ...	-	-	-	-	-	1,300-lbs. phosphorus, 104 bbls. sulphur used; 49,000 gross made.
Brook emptying into above.	Match Factory (Messenger & Sweet), .	-	-	-	-	11	Run 9 months in the year.
Branch of Wading River.	Saw Mill (C. D. & O. H. Lane), . .	-	-	-	-	-	
	Saw Mill, ...	-	-	-	-	-	
	Saw Mill, ...	-	-	-	-	-	

River-Statistics, Mills, Factories, etc., of the Taunton Valley—Continued.

NAME OF STREAM OR BRANCH.	Letters corresponding with Letters on Map.	DESCRIPTION OF MILL, ETC.	Location.	No. of Hands Employed.	No. of Spindles.	Head and Fall.	Quantities of Materials used per year, so far as known.
Wading River,	.	Shingle and Saw Mill (J. T. Braunan), .	Norton, .	2	-	Feet. 4	Runs most of the year.
	.	Saw, Grist and Planing Mill (Sweet Bros.),	Mansfield, .	5	-	9	Runs all the year.
	.	Cotton Mill (J. W. Sayles), . . .	Mansfield, .	-	-	-	
	.	Knife Works (G. A. Robinson), . .	Mansfield, .	17	-	12	20,000 doz. knives made; used 150 lbs. bees-wax, 100 lbs. tallow, 250 lbs. pig-lead.
	.	Wool Scouring Mill, ...	Wrentham, .	-	-	8½	Has not been in operation for a year.
	.	Saw and Grist Mill, ...	Wrentham, .	2	-	10½	Mill runs 4 months in the year.
	.	Woolen Yarn Mill (Henry Cook's), .	Wrentham, .	18	-	22	52,000 lbs. wool used when running full; wool also washed.
	.	New reservoir just above last mill, .	Wrentham, .	.	.	4	No mill here.
	.	Old dam not used now, ...	Wrentham, .	.	.	4	
	.	Mill (Crowels), ...	Wrentham, .	-	-	9½	Not in use.
Cocasset River,	.	Reservoir N.W. of Shepard's Pond,	Wrentham, .	.	.	7½	No mill here. Dam is not up (Sept., 1875).
	.	Leather Board Mill (W. W. Wait), .	Foxborough, .	4	-	14	90 tons leather board made per year; 1 bbl. lime used.
	.	Iron Foundry (Carey's), ...	Foxborough, .	11	-	24	156 tons iron; 2 carboys sulph. acid used per year.

Cocasset River,	Paris Hat Factory, imitation straw (Kendall & Trested), Reservoir N. W. of above,	Foxborough,	-	10	Not in operation for 2 years; fall given is at overflow, could not get at wheel. No mill here.
	Laundry, ...	Foxborough,	8	6	2,600 doz. shirts, 5,200 doz. collars, 5,200 doz. handkerchiefs washed per year; dirty water turned into the stream. 100,000 lbs. wool washed per year; 2,000 lbs. soda-ash, 9 tons salt. No mill here.
	Wool Scouring Mill (C. Freeman & Son), Reservoir south of above, ...	Foxborough,	17	24	
	Reservoir south of above, ...	Foxborough,	15	7	Business amounts to \$20,000 per year.
Taunton River,	Fire-brick and Stove-Lining Works (J. Williams). Tack Factory (Anthony & Cushman), ...	Taunton, ... Taunton, ...	56	Steam.	360 tons iron, 3 tons copper, 29 tons zinc, 2½ tons steel. Plate cut into tacks and nails; 300 carboys sulph. acid used.
	Stove-Lining Works (Presbrey & Co.), ...	Taunton, ...	-	Steam.	500 tons iron; 12 carboys sulph. acid used.
	Taunton Iron Works, ...	Taunton, ...	100	Steam.	25 carboys sulph. acid, 6 carboys nit. acid.
	Copper Works (Crocker Bros. & Co.), ...	Taunton, ...	80	Steam.	
	Crucible and Stove Polish W'ks (Phoenix M'fg Co.) Crucible Works, ...	Taunton, ... Taunton, ...	18	Steam.	
	Tack Works (A. Field & Sons), ...	Taunton, ...	415	4	3,300 tons iron, 100 tons zinc, 25 tons copper, 20 tons steel, 75 tons brass for eye-lets. Plate cut into tacks and nails; 1,200 carboys sulph. acid, 12 carboys nit. acid used.
	Tack Works Taunton Tack Co., ...	Taunton, ...	100	Steam.	750 tons iron made into tacks; 30 carboys sulph. acid, 1 keg sal-am. used per year.
	Copper Works (Crocker Bros. & Co.), ...	Taunton, ...	27	15½	Copper rollers for print-works, tinned copper-plate and yellow metal; 20 carboys sulph. acid used per year.
	Silver-Plating Works (T. S. P. Co.), ...	Taunton, ...	60	Steam.	Briannia and silver-plated ware; 12 carboys sulph. acid, 600 lbs. potash, 150 lbs. cyanide of potash used.

h

i }
j }Small brook empty-
ing into Taunton R.
Taunton River,

Little or Mill River,

River-Statistics, Mills, Factories, etc., of the Taunton River—Continued.

NAME OF STREAM OR BRANCH.	Letters corresponding with Letters on Map.	DESCRIPTION OF MILL, ETC.	Location.	No. of Hands Employed.	No. of Spindles.	Head and Fall.	Quantities of Materials used per year, so far as known.
Little or Mill River,	k	Screw Manufactory, American S. Co.,	Taunton,	325	-	Feet. 6	624 tons iron. Works are to be removed to Providence, R. I.
		Gas Works,	Taunton,	8	-	-	13,000,000 cubic feet gas made 1874; 17,000 tons coal used.
		Machine and Foundry Shop,	Taunton,	77	-	Steam.	35 carboys sulphuric acid.
		Cotton Mill (Dean Cotton & Mach. Co.),	Taunton,	85	5,360	8½	216,000 lbs. cotton made into white cloth.
		Cotton Mill,	Taunton,	42	4,064	Steam.	624,000 lbs. cotton spun into yarn.
		Cotton Mill (Chas. Albro),	Taunton,	40	7,584	15½	318,000 lbs. cotton made into white cloth.
Canoe River,	l	Britannia Works (Reed & Barton),	Taunton,	450	-	7	
		Cotton Mill (Whitenton Mfg Co.),	Taunton,	900	-	15½	2,000,000 lbs. cotton made into white and colored cloth.
		Shingle Mill,	Norton,	-	-	-	
		Batting Mill,	Norton,	-	-	-	
Branch of Canoe R.,	m	Grist and Saw Mill (J. B. Flint),	Mansfield,	4	-	14	
		Tack Factory (F. A. White),	Mansfield,	-	-	16	Has not been in operation for 2 or 3 years.
		Cotton Batting Mill,	Mansfield,	-	-	9	Has not been in operation for 6 years.
Leaches Stream,		Saw Mill,	Foxborough,	-	-	-	
		Iron Foundry (T. Copeland),	Norton,	4	-	8½	Runs 4 months a year.

Branch of above,	Saw Mill, ...	Easton, ...	-	-	7	
Leaches Stream,	Saw Mill, ...	Easton, ...	-	-	10	
	Iron Foundry (Drake's), ...	Easton, ...	25	-	16	Cast 650 tons iron per year; 45 carboys sulph. acid used.
	Iron Foundry Malleable Iron (Belcher's), ...	Easton, ...	20	-	-	
	Grist Mill, ...	Easton, ...	-	-	14	
	Factory (Briggs), ...	Sharon, ...	-	-	-	Not in operation. Pond not kept up.
Two Mile Run,	Saw and Grist Mill (M. G. Williams), ...	Raynham, ...	3	-	9	Runs all the year.
	Nail Mill, ...	Raynham, ...	-	-	-	Not in operation.
	Shoe Factory (W. O. Snow), ...	Raynham, ...	67	-	13	Uses \$80,000 worth of stock per year.
	Saw Mill (J. Tracy & Son), ...	Raynham, ...	-	-	-	
	Tack Factory (Leeds, Robinson & Co.), ...	Raynham, ...	14	-	15	3,000 casks lath nails; 250 carboys sulph. acid.
	Saw and Planing Mill (M. Wilbur), ...	Raynham, ...	-	-	13	Run all the year.
	Shingle and Grist Mill (M. Wilbur), ...	Raynham, ...	-	-	-	
Damlot Brook,	Nail Factory (small one), ...	Raynham, ...	-	-	-	Not in operation.
Cotley River, . .	Saw Mill (H. S. Dean), ...	Taunton, ...	-	-	9	Not in operation.
	Charcoal Mill, ...	Taunton, ...	-	-	7	Not in operation, grind charcoal for four-dry facings.
	Extension Table Factory, ...	Taunton, ...	-	-	13	Not in operation. Dam not up.
Taunton River,	Iron Works, ...	Taunton, ...	325	-	13	3,000 tons plate-iron, 100,000 casks nails, 10,000 doz. shovels; 150 carb. sulph. acid
Brook, ...	Saw Mill (N. S. Williams), ...	Taunton, ...	4	-	13	Runs all the year. [used.]

River-Statistics, Mills, Factories, etc., of the Taunton Valley—Continued.

NAME OF STREAM OR BRANCH.	Letters corresponding with Letters on Map.	DESCRIPTION OF MILL, ETC.	Location.	No. of Hands Employed.	No. of Spindles.	Head and Fall.	Quantities of Materials used per year, so far as known.
Brook, . . .		Saw and Box Mill (Robinson, King & Co.)	Taunton, .	3	1	Feet. 7	
		Saw Mill (Dean Factory Pond), .	Taunton, .	3	1	20	Runs all the year.
Brooks entering Taunton River.		Grist Mill, . . .	Middleborough, .	1	1	—	
		Shingle Mill, . . .	Middleborough, .	1	1	—	
		Nail Factory (B. O. & C.), .	Lakerville, .	1	1	—	
		Tack Factory, . . .	Bridgewater, .	1	1	—	
		Saw Mill (Keith's), . . .	Bridgewater, .	1	1	—	
Namasket River, .	y	Shingle Mill, . . .	Middleborough, .	1	1	—	
		Grist and Saw Mill, . . .	Middleborough, .	1	1	—	
		Grist and Saw Mill, . . .	Middleborough, .	1	1	—	
		Woolen Mill (Star), . . .	Middleborough, .	101	1	—	300,000 lbs. wool, 2,500 lbs. soda-ash, 33 tons logwood, 19 tons soap.
		Shovel Factory (Middleboro' Shovel Co.),	Middleborough, .	30	1	9	3,120 doz. shovels made per year.
		Varnish Factory (Shavos), . . .	Middleborough, .	3	1	Steam.	2,080 bbls. japan, 780 bbls. varnish made.
Fall Brook, . . .		Dam, . . .	Middleborough, .		17	17	No mill here now.

Fall Brook, . . .	w } x }	Saw Mill and Spool Factory (E. Mills), . . .	Middleborough, . .	-	10	Not in operation (Oct., 1875).
Streams entering Long Pond.		Saw and Shingle Mill (Sumner & Hinds), . .	Lakeville, . . .	2	17	Runs 7 months in the year.
		Box Board, Shingle and Grist Mill, . . .	Freetown, . . .	5	15	Runs 9 months in the year.
		Saw and Shoddy Mill (H. E. Foster), . .	Freetown, . . .	5	9½	Runs 8 months in the year.
	y z	Saw Mill (P. M. Burns), . . .	-	2	18	Runs 3 months in the year.
Black Brook, . .		Saw Mill, . . .	Rochester, . . .	-	-	-
		Grist Mill, . . .	Rochester, . . .	-	-	-
		Saw Mill, . . .	Middleborough, . .	-	-	-
Bartlett's Brook, .	C	Saw Mill, . . .	Halifax, . . .	-	8½	Mill not in operation.
Small streams, . .		Saw Mill, . . .	Halifax, . . .	-	-	-
		Saw Mill, . . .	Halifax, . . .	-	-	-
		Saw Mill, . . .	Halifax, . . .	-	-	-
Raven Brook, . .	a¹	Saw Mill, . . .	Halifax, . . .	-	7	Mill not running.
		Saw Mill (Cox's), . . .	Middleborough, . .	3	7	-
		Box Mill, . . .	Middleborough, . .	3	12	-
Whetstone Brook, .		Saw Mill, . . .	Plympton, . . .	3	15	Not in operation. Water much colored (Oct. 1875).
		Saw Mill (Savory's), . . .	Middlebrook, . . .	-	10½	Mill burned some years ago. Water much colored.
		Ruins of Shovel Factory, . . .	Middlebrook, . . .	-	13	Mill burned some years ago. Water much colored.
		Woolen Mill, . . .	Plympton, . . .	-	14	Mill burned some years ago.
Winetuxet River, .		Shovel Factory, . . .	Plympton, . . .	-	8	Mill burned four years ago.
		Grist Mill, . . .	Plympton, . . .	-	7½	Mill not in operation.

River-Statistics, Mills, Factories, etc., of the Taunton Valley—Continued.

NAME OF STREAM OR BRANCH.	Letters correspond- ing with Letters on Map.	DESCRIPTION OF MILL, Etc.	Location.	No. of Hands Em- ployed.	No. of Spindles.	Head and Fall.	Quantities of Materials used per year, so far as known.
Winetuxet River, .		Cotton Mill (Jenkins Bros.), .	Plympton, .	14	—	Feet. 12	140,400 lbs. cotton used per year.
Annasnappet Brook,		Saw Mill (Earl Sherman), .	Plympton, .	—	—	7	
Winetuxet Brook, .		Grist and Saw Mill (Coles), .	Carver, .	3	—	10	
Stream entering Col- chester Brook.		Saw Mill, ...	Halifax, .	—	—	10	Not in operation. Dam not up.
Colchester Brook, .		Box and Saw Mill (J. S. Bonney), .	Plympton, .	—	—	9	Not in operation.
Taunton River, .	b ¹	Paper Mill, ...	Bridgewater, .	14	—	8	300 tons manilla paper made; 12 carboys sulph. acid used.
		Grist Mill, ...	Bridgewater, .	2	—		
		Grist Mill, ...	Bridgewater, .	2	—		
South Brook, .	c ¹	Box Factory, ...	Bridgewater, .	—	—	12½	5,000 tons scrap-iron, 500 tons pig-iron, 400 tons Swed. iron, 250 tons old iron, 6,000 tons coal, 624 carb. sulph. acid, 800 tons brass for tubes, 1,872 gals. mur. acid.
Town River, .		Bridgewater Iron Works, .	Bridgewater, .	550	—	—	
	d ¹	Grist Mill (Oliver Ames & Sons), .	W. Bridgewater, .	2	—	9½	
		Saw Mill, “ “	W. Bridgewater, .	2			Runs all the time.
		Shovel Shop, “ “	W. Bridgewater, .	9			Runs 7 months in the year.
		Shingle Mill, ...	W. Bridgewater, .	2	—	—	

West Meadow Br ^k ,	Saw Mill, ...	W. Bridgewater, .	-	-	-	-
Hocamock Brook, .	Saw Mill (Wood's), ...	Brockton, ...	2	-	8	-
	Saw Mill (Drew's), ...	Brockton, ...	2	-	7	-
	Saw Mill, ...	Brockton, ...	-	-	-	-
	Batten Mill (E. J. W. Morse), ...	Easton, ...	-	-	8	Not in operation.
	Machine-Shop (Thos. Dean), ...	Easton, ...	7	-	} 12	62,400 lbs. cotton made into thread and twine.
	Grist Mill (T. & J. O. Dean), ...	Easton, ...	3	-		
	Thread Mill (E. J. W. Morse), ...	Easton, ...	30	-	9	Has not been in operation for some time. 149,760 doz. shovels made per year. 250 carboys sulphuric acid.
	Shovel Shop (O. Ames & Sons), ...	Easton, ...	2	-	8½	
	Awl Factory (small shop), ...	Easton, ...	-	-	5	
	Hinge Factory (E. W. Gilmore & Co.), ...	Easton, ...	-	-	12	
	Shovel Works (O. Ames & Sons), ...	Easton, ...	450	-	18	
	Hammer Shop (O. Ames & Sons), ...	Easton, ...	-	-	18	
	Hammer Shop (O. Ames & Sons), ...	Easton, ...	4	-	14½	
	- - - - -	E. Bridgewater, ...	-	-	10	
	Jute Works, ...	E. Bridgewater, ...	-	-	7	
	- - - - -	E. Bridgewater, ...	-	-	9	
	Saw Mill, ...	E. Bridgewater, ...	-	-	-	
	Saw and Planing Mill (Goss), ...	E. Bridgewater, ...	4	-	16	Runs all the time.

River-Statistics, Mills, Factories, etc., of the Taunton Valley—Concluded.

NAME OF STREAM OR BRANCH.	Letters correspond- ing with Letters on Map.	DESCRIPTION OF MILL, Etc.	Location.	No. of Hands Em- ployed.	No. of Spindles.	Head and Fall.	Quantities of Materials used per year, so far as known.
Beaver Brook,	h ¹	Saw Mill (J. A. Young), ...	E. Bridgewater, .	3	-	Feet. 19	Runs all the time.
		Hosiery Mill, Cotton and Woolen, .	E. Bridgewater, .	40	-	6½	100 bbls. soft soap. No wool cleaned here.
		Box Board Mill, ...	Abington, . .	-	-	-	
		Shingle Mill, ...	Abington, . .	-	-	12	
Matfield River,		Iron Works (Rogers & Sheldon), .	E. Bridgewater, .	65	-	18	2,500 tons iron made into nails, etc.
Salisbury Plain Riv.,		Saw Mill (S. D. Shaw), ...	E. Bridgewater, .	-	-	12	
	i ¹	Fertilizer Factory (Ward's), . . .	W. Bridgewater, .	-	-	6	Not doing much at present.
		Saw Mill (O. F. Curtis), ...	Brookton, . .	} 25	-	9	20,000 pairs lasts made per year.
		Last Factory (O. F. Curtis), . . .	Brookton, . .		-	8	
		Last and Boot-Tree Factory, . . .	Brookton, . .	7	-	8	
		Boot and Shoe Shop (Martin Wilde), .	Brookton, . .	100	-	Steam.	
		Grist and Planing Mill, ...	Brookton, . .	-	-	-	
		Shoe Tool Factory, ...	Brookton, . .	-	-	8	
		Last Factory, ...	Brookton, . .	-	{	Also use	
		Shoe-String Factory, ...	Brookton, . .	-		Steam.	

Salisbury Plain Riv.,	Saw Mill (Marcus Leach),	Brockton, .	-	10½ also use Steam.	
	Shoe Shop (F. Packard),	Brockton, .	115	-	
	Shoe Shop (Lincius Leach),	Brockton, .	-	-	
	Grist Mill (F. F. Wheeler),	Brockton, .	-	8	
	Tack Works (W. W. Cross),	Brockton, .	10	6	
	-	E. Bridgewater.	-	-	
Satrucket River, .	Saw Mill, .	E. Bridgewater, .	-	-	
Black Brook, . .	Tack Factory (small one),	Hanson, .	5	8½	
Br. of Poor Meadow River.	Grist and Saw Mill, .	Hanson, .	-	9	Not in operation.
	Boot and Shoe Shop (Reed & Closson),	Abington, .	200	Steam.	10,000 cases boots and shoes made per year.
	Tack Factory (Brigham, Litchfield & Vining).	Abington, .	50	Steam.	650 tons iron, 1 ton copper, 100 tons zinc, 5 tons steel, made into tacks and nails.
	Eyelet Factory (Dunbar & Rhodes),	Abington, .	-	Steam.	
	Box Factory (Atwood's),	Abington, .	-	Steam.	
	Tack Factory (Dunbar, Hobart & Whidden).	Abington, .	300	11	2,250 tons tacks made; 600 carboys sulph. acid used.
	Saw Mill, .	Halifax, .	-	-	
Small streams,	Saw Mill, .	Hanson, .	-	-	

j¹k¹

River-Statistics, Taunton Valley, Summary.

	Number.	Operatives Employed.
Woolen Mills.	4	171
Cotton Mills, ...	10	1,419
Iron Works, ...	30	3,317
Paper Mills, ...	3	35
Silver-plating, Jewelry and Watchmakers, . . .	4	615
Shoe-shops, ...	4	482
Laundry, ...	1	8
Fire-brick and Crucible Works, ...	3	39
Saw and Grist Mills, ...	87	—
	146	6,086

Mr. Fuller gives the following additional notes :—

"Of the height of the water, when samples were taken, I would say that I think the water was as low as it has been this summer. The season has not been a dry one, there having been frequent rains, and probably the river has not been so low as it generally is in the summer season.

"The Taunton Valley is not rocky. There is no limestone, and I think no quarries of any stone. A stone, called white stone, is found in the vicinity of Long Pond, in Freetown. It is used in making iron furnaces. Field boulders of granite are met with.

"The common river and pond fish are found through the entire valley; viz., red and white perch, pickerel, shiners, flat-fish, horned pouts; in some of the ponds, bass have been placed. In the main river there are also, in the spring, herring. I do not think any fish have been driven off by the polluting refuse of mills or by the sewage of towns.

"Little or Three Mile River receives the polluting refuse of

the Taunton gas-works, and also that portion (small) of the sewage of Taunton which drains into the river. Yet this stream contains the fish above named.

"Population of villages delivering in part, or likely to deliver sewage into stream:—

North Dighton,	.	.	.	.	.	477
Taunton,	.	.	.	.	.	20,429
Mansfield Centre,	.	.	.	.	.	1,000
Foxborough,	.	.	.	.	.	1,497
Middleborough Four Corners,	.	.	.	.	.	1,800
Namasket Village,	.	.	.	.	.	800
Bridgewater,	.	.	.	.	.	1,600
Joppa Village,	.	.	.	.	.	800
North Easton,	.	.	.	.	.	1,950
Brockton (N. Bridgewater),	.	.	.	.	.	5,000
South Abington,	.	.	.	.	.	1,000
Winetuxet Village,	.	.	.	.	.	400

"The water was generally quite strongly colored; *i. e.*, of a brownish tint. This, I think, was especially true of the eastern part of the valley. The ponds were lighter colored; Elder's Pond being one of the clearest I have ever seen."

In answer to the inquiry, whether the presence of iron ore led to the establishment of so many iron-works in the Taunton Valley, Mr. L. S. Drake, of Easton, gives Mr. Fuller the following statement:—

"There are in this vicinity (Easton) small beds of bog ore, and this fact would account for the establishment of iron-works at this place.

"As near as can be learned, a blast foundry was put in operation at this place about 1770, and was run as a blast furnace, making iron castings from the ore, until about 1855. For some years previous to this last date, the stock of ore in this neighborhood had become so reduced that supplies were obtained from Cranston, and Cumberland, R. I., and also from New Jersey; a better quality of casting being obtained by this mixture of ores than from the old neighborhood ore.

There are, without doubt, some small beds in existence in the northern part of this town, and in Sharon, West Bridgewater, Mansfield, and other adjoining towns. The bottom of Massopog Pond, in Sharon, being an ore-bed, the right to use the same, still belongs to the heirs of Gen. Leitch, who at one time was the largest iron-man in the State, he running blast furnaces at Easton, Foxborough, Walpole and North Chelmsford. The fact of this being an iron region would account for the establishment of the iron-works in Bridgewater. But, as regards the iron-works in Taunton, I think that they were started as business investments, and not from the fact of the ore region, as in the case of the other establishments mentioned. Since 1835, the iron used here is obtained from other States; no iron being made from the ore since that time in any of the foundries I have mentioned."

ANALYSIS OF STATISTICS.

In the following table the statistics are condensed as before of some of the points on the streams from which samples of water were taken for analysis. The results of the analyses can here be compared with the measure of pollution.

In the second table will be found, grouped from Prof. Nichols' tables, the analyses of the waters taken from the points indicated in the one previous to it; the letters will show the positions of these points on the map. Several examples of the character of the head waters are also given.

TAUNTON RIVER VALLEY—Condensed Statistics for a few of the Points from which Samples of Water were taken for analysis.

NAME OF PLACES,	a	b	j	(B) t	c	a	b
	Near North Dighton.	On Three Mile River.	On Mill River.	Taunton Riv. E. Taunton.		On Wine- tuxet River.	On Town River.
Drainage-area in square miles above points indicated, ...	447.	83.	47.	283.	177.	36.	137.
Dry-weather flow at respective points in 24 hours, cub. feet, ...	9,655,200	1,792,800	1,015,200	6,112,800	3,823,200	777,600	2,959,200
The same in U. S. gallons, ...	72,220,896	13,410,144	7,593,696	45,723,744	28,597,536	5,816,448	22,134,816
Number of polluting factories or mills above respective points, ...	59	17	14	20	17	1	16
Number of polluting factories or mills above respective points per square mile.	.13	.20	.29	.07	.10	.03	.11
Number of operatives in said mills, ...	6,401	687	2,624	2,419	1,963	14	1,949
Population in basin above respective points in 1875, ...	65,482	8,968	12,470	33,814	26,609	1,562	25,047
Population in basin per square mile, ...	144.5	108.0	265.3	119.5	150.3	43.4	182.8
Population of cities, villages, mills or works severing into the river above said points.	12,200	1,450	4,600	4,150	3,750	50	3,700
Population of this character per square mile, ...	27.1	17.5	97.9	14.6	21.2	14.	27.0

Analysis of the Waters of the Taunton River.

[Parts in 100,000.]

DATE.	Letters on Map.	LOCALITIES.	Ammonia.	"Albuminoid Ammonia."	SOLID RESIDUE.		Chlorine.	Oxygen required.
					Organic.	Total.		
Aug. 17, 1875,	n	Leaches Stream, above pollution,	.0043	.0171	2.16	4.56	0.28	0.815
" 17, 1875,	g	Ames Pond, above all pollution,	.0053	.0165	1.28	3.36	0.27	0.427
" 20, 1875,	k	Mouponset Pond, above pollution,	.0133	.0171	2.36	4.76	0.44	0.198
" 5, 1875,	b ¹	On Town River or Upper Taunton,	.0075	.0211	-	6.16	0.31	1.608
" 5, 1875,	a	Whetuxet River,	.0091	.0229	3.80	7.64	0.46	-
July 30, 1875,	t	Taunton River, near East Taunton,	.0069	.0235	2.56	5.32	0.42	1.359
" 28, 1875,	q	Taunton River, near Taunton,	.0080	.0208	2.56	5.64	0.40	1.438
" 28, 1875,	j	On Mill River,	.0123	.0245	2.24	4.92	0.33	0.787
Aug. 4, 1875,	b	On Three Mile River,	.0080	.0181	1.96	4.40	0.32	0.713
" 4, 1875,	a	Taunton River, near North Dighton,	.0085	.0197	4.32	16.00	5.50	1.012

In the last example of this table, from water taken near North Dighton, there is evidence of some mixing of the salt water with the fresh. In the other examples, the water taken from Town River and from Winetuxet River, show larger proportions of solid residue than any of the others, except the last; and yet the pollutions to which those streams are exposed at these points are much less than for any of the other examples, and they could not be condemned now on that account. This river was not at its lowest dry-weather stage when the samples of water were taken for the chemist, nor has this stage been reached this season, so far as I can learn, upon this or any of the rivers examined by us.

Of the waters examined from this valley, Prof. Nichols remarks:—

"The waters of the great ponds (such as Assawampsett, Great Quittacas, Little Quittacas), and of some of the brooks at the head waters of the Taunton River, are clear and colorless. The water of the river itself, and of its main tributaries, is quite strongly colored with vegetable matter, probably in part at least combined with iron, which occurs to a greater amount in the waters of this stream than in that of some of the others examined.

"The waters, like those of most rivers, are slightly alkaline, less so as a rule than those of the Chicopee or Blackstone, and much less so than the Connecticut, at Springfield. On two occasions only have I observed other than an alkaline reaction. Samples of water were taken at two different times at East Taunton, above and below the Old Colony Iron Works. The sample taken August 6th, below the works, was slightly but distinctly acid. The other occasion was August 5th, when specimens were taken above and below the Bridgewater Iron Works. The specimen taken above the works was slightly alkaline; that taken below was neutral,—neither acid nor alkaline. This would seem to indicate that at times a small amount of acid liquor is allowed to run into the river.

"The only specimen polluted to any considerable extent was No. 39 (e on the map), taken below a wool-scouring establishment. This specimen was very turbid, and did not become clear on standing.

"The greasy-looking suspended matter was seen, under the microscope, to contain bits of animal hair (wool), and epithelial cells, besides animal and vegetable microscopic growth.

"The tables show that the influence of the salt water is felt above the entrance of Three Mile River, but not as far as the entrance of Little River (Mill River); also I think the tide has no influence on the water at 'Shallow Water,' from which point it is proposed to take the water-supply of the city of Taunton, the differences not following any regular law. I think the examination further shows that, while undoubtedly the most desirable water-supply for the city of Taunton is offered in the great ponds, yet the river is able to afford water sufficient and practically pure for domestic purposes, and superior to most, if not all, the water at present derived from wells."

In the accounts of the different valleys, one of the tables in each case presents among other data, what is there called the "dry-weather" flow of the stream, that the reader might understand something of the small volume of water which prevails in a low season of rainfall. The polluting refuse received into the particular stream may remain about the same per day for each month of the year, but, whereas its effect could not be perceptible during a flood, its proportion to the volume of water flowing down stream becomes greater and greater as the water gets lower, until, during its days of minimum water, it may, even when not otherwise excessive, foul the stream so as to render it unfit for any use then.

The dry-weather flow does not mean the minimum flow, which will sometimes not reach one-half of the other. The dry-weather flow is meant to represent the average of four to six weeks of the lowest stage of the river during an unusually dry summer. The dams and works on the river generally admit of this average being secured, and obliterate, so to say, the extreme minimum flow, which would in a natural state of the river-bed otherwise frequently be exhibited.

The following gaugings have guided me in deciding on the rates of flow assumed in these tables.

The Charles River, as gauged in August, September and October, 1845, by John B. Jervis and Walter P. Johnson,

gave an average of 19,108,451 U. S. gallons per diem through the month of September. The point chosen was above Newton Upper Falls, but below the Mother Brook. The Mother Brook draws off into the Neponset River, one-third of the water running in the Charles River. The natural flow per diem, for September, 1845, would therefore be 28,662,676 gallons. The drainage-area for this point is two hundred and thirty-six square miles; the flow per square mile therefore is 121,452 gallons per diem = 16,235 cubic feet, giving a rate of 0.188 cubic feet per second per square mile.

Mr. Davis states that the flow of the Sudbury in the early part of November, 1874, as determined by accurate gauging, was 135,000 gallons per square mile of water-shed per diem. This is equal to 0.209 cubic feet per second per square mile.

The outlet of Flax Pond at Lynn was gauged by Mr. Fteley for Mr. Davis, from November 24 to December 13, 1874, at the height of the drought. The yield averaged 128,400 gallons per square mile of the water-shed, which is equal to 0.198 cubic feet per second per square mile.

The only gauging which I have of the Merrimack River shows a much larger rate of summer-flow. A note from Mr. James B. Francis gives me the following information: "A gauge made of the flow of the river here (Lowell), July 24 and 25, 1840, when it was called unusually low, gave 1,488.63 cubic feet per second. Another, during the same drought, "August 2 and 4, 1840, gave 1,505.91 cubic feet per second. This was before we had any control of the lakes and reservoirs."

The water-shed above this point is estimated at 3,598 square miles.

This gives a rate of 0.416 cubic feet per second, which is more than double of the gauging on the smaller streams given above. The lakes and reservoirs on this water-shed must have affected the result, although they were not utilized then for mill-power to the same extent as now.

The first three instances, as belonging more nearly to the grounds which have been examined this season, have been taken as a sufficient guide in this instance. The average of these is 0.198 cubic feet per second per square mile. I have taken it at 0.200 per second for the Chicopee River, the

Charles River, and the Neponset, and at 0.250 per second per square mile for the Blackstone River and the Taunton River.

This larger rate for the Blackstone was taken in deference to the opinion of the assistant engineer, whose observations and calculations of the low summer-flow gave larger results than my own estimates.

In the case of Taunton River, the numerous small ponds in that valley led me to believe that they must to some extent, by their united storage, add to the low-water flow of that stream.

PART III.—GENERAL CONCLUSIONS.

In comparing, as has been done, the waters taken from the head and foot of each river, so to say, and from intermediate points, the inferences which have been drawn, or which could be drawn, from these chemical examinations, are not to be considered as expressing the whole truth; but only that part of it which analysis can reach; the exact influence or even presence of the sewage and trade-pollutions which may have passed into a stream cannot be discovered by the chemist, when minute in quantity. The poisons may be so largely diluted as to be beyond the readings of analysis, and yet they may be sufficient, when fairly presented and understood, to render the water, by reason of that knowledge, not merely repulsive or suspicious, but more or less dangerous for family use.

The opinion of the English Rivers-Pollution Commission was very decided on this point at the date of their writing (1868): "No process has yet been devised of cleansing surface-water once contaminated with sewage, so as to make it safe for drinking." And again: "Among the numerous processes for the cleansing of polluted water with which we have been acquainted, there is not one which is sufficiently effective to warrant the use for drinking of water which has once been contaminated with sewage or other similar noxious animal matters."

If this view of the case may seem to be overcautious, it is to be remembered that the poison, however trifling, is taken daily, and that although when in robust health the individual will not suffer from it, it may be sufficient to make itself felt

when he is prostrated by sickness and his powers of resistance to such influences are then proportionally impaired.

We have therefore, as Dr. Frankland says, always to ascertain and keep in view the character of the stream as regards exposure to pollution, and, if it has received much filth in its course, to consider its waters objectionable and to be avoided if possible for human use; unless, indeed, the volume of the stream should be so great, compared with the filth-pollution, as practically to be independent of such reasoning.

As an instance confirmatory of these remarks, take the water of the Blackstone River at the point where it crosses the state line, near Blackstone.

The river reaches this point, carrying with it the sewage of the city of Worcester, the refuse waters of thirty-six woolen mills, twenty-three cotton mills, six iron-works, a tannery and a slaughter-house,—these works employing 7,200 hands, much of whose ablutions and sewage passes into the river.

The sewage of Worcester may be taken at a	
minimum per day of	2,000,000 gals.
The sewage of the mill operators and their	
families, at	36,000 “
The fluid refuse of the mills it is difficult	
to estimate even approximately; it was	
estimated by the assistant engineer at	
2,678,000 gallons—say, ...	2,500,000 “
Gallons per diem, ...	4,536,000
Equal to 606,508 cubic feet per diem.	

At Blackstone, the dry-weather flow of the river is taken at 5,961,600 cubic feet per diem.

This last includes the polluted waters as above estimated. We have therefore in this case, 5,355,092 cubic feet of unpolluted water mixed with 606,508 cubic feet of badly polluted water.

The sewage and refuse waters delivered into this river amount, then, by this estimate, to a little over ten per cent. of the average dry-weather flow of the stream at Blackstone,

a degree of contamination which will be admitted to be condemnatory of that water; but, when the sample of water was taken for analysis (July 10), the river was not at its lowest summer stage, which generally occurs much later in the season. The flow in the river was not gauged at the time that the sample was taken for analysis, but its rate at that time might probably be about double of the dry-weather flow of a low season of rainfall, which would reduce for that date the proportion of the Worcester and trades sewage to over five per cent. of the volume of water running at Blackstone.

None of the rivers examined by us have this season reached the low stage of water referred to; they have all been in a low summer stage when the samples of water were taken, but not exceptionally so; and yet this exceptionally low stage must be encountered, sometimes for months, during very dry years. The pollutions received must, then, be applied to this measure to understand the degree of foulness to which the stream will be subject, noting, however, that during the very dry stage referred to, while the pollution from sewage will not be reduced, the pollutions from trades refuse will be diminished considerably, whenever for want of water the factories are obliged to intermit or work half-time.

The analysis fails to show much difference between the water of the river at this point and its head waters—not enough to condemn the water for domestic use or any other use; but if you mix five per cent. of sewage-water with ninety-five per cent. of unpolluted river-water, the chemist could hardly fail, we should suppose, to discover some evidence of pollution. If this be so, we cannot avoid the inference, notwithstanding what has been said, and notwithstanding the opinions of eminent English chemists, that in the course of its movement over some twenty miles of the river channel, the sewage fluids in this case have lost some of their impurities, and that the analysis is not entirely at fault in encouraging this inference.

Of our rivers enough has been said, now and heretofore, to show that any defence of their waters against the impurities which so conveniently flow into them from the settlements and works on their banks, has thus far been merely nominal; that is, the law can be used to prevent a nuisance from con-

tinuing to be poured into the river, but it is not used because the process is too slow, cumbersome and expensive.

To change this state of affairs, and to remedy it radically, is the problem now presented; and, while those who have been obliged to study the subject are confident that it is not insoluble, it is full of that kind of difficulty to overcome which will demand great perseverance, some experimenting, and, it may be, considerable invention and ingenuity. Not that there has not been much done in Great Britain to give direction to whatever may have to be done here, but our severe winter climate presents a difficulty by itself which will require special treatment; and, while there appears to be nothing insurmountable in dealing with it, it will probably add to the expense of all the purifying processes necessary to meet the different kinds of pollution to be dealt with. Every process will have in some degree to be tentative on this account, until the simplest and most economical mode of meeting the case is reached.

THE PREVENTION OF POLLUTION.

The law requires the Board of Health "to devise a system by which said rivers, estuaries and ponds may be protected against pollution, so far as possible, all with the view to the preservation of the health of the inhabitants of this Commonwealth."

To devise and perfect a system as varied in its modes of action as the fluid impurities emanating from the different kinds of works and from ordinary sewage will require, must, as has been hinted above, be a work of time; and, while authority must be lodged somewhere to begin this work, and probably to expend some money in ascertaining sometimes how to begin, it seems obvious that the authority given, should, in fairness to cities and manufactories, be exercised in the first instance only conditionally, and that in the case of any fluid impurities requiring to be stopped from entering the stream and to have their poisonous qualities destroyed, and the residue rendered innocuous before being passed into the stream, the authority having the power to require this course should be required to show how it can be done, and the apparatus or material required to effect it. In other

words, that authority must be prepared to indicate or teach the mode of purification before taking legal action against it, the party required to act in the particular case being, however, at liberty to follow any process which he may prefer having in view the same end.

It may be further remarked in this relation, that the authority indicated should have the power to interfere with the pollution by steps, if advisable, perfecting such processes thereafter as circumstances admit of it. This might operate better than attempting that thoroughness of purification which may be practicable at once, inasmuch as entire purification will not probably in any case be attainable.

It may seem out of place in this paper to notice this phase of the subject, but its consideration is not easily avoided, and the allusion to it grows naturally out of the subject.

As an instance of the kind of difficulty which will have to be studied and overcome, the application of sewage to irrigation may be mentioned. Of all the modes of dealing with sewage, this may be said to be the favorite, inasmuch as it undertakes in a more simple way than any other to apply the fluid sewage upon land so as to make it as largely remunerative as possible. But there are two kinds of irrigation in this connection,—the irrigation which, whether using water or sewage, applies it to the crops only as required and in quantities calculated to produce the best results. This kind of irrigation may be said to be always profitable; but, in this case, what is not wanted is not purified, and the overplus of that which has been used is not purified, although it has been somewhat deprived of its noxious qualities.

The other kind of irrigation is that which has in view, not merely the utilization, but also the absolute purification of the sewage-water. In this case there must be, first, such a liberal extent of land provided as will admit of the sewage during the growing season, at least, being entirely used by the different crops, arranged to that end. The process of irrigation, to produce the best results, being always intermittent, the grounds are broken up into many divisions or plots (the circumstances prescribing their size and number), so that the sewage-fluids can be transferred at will from one plot to another, or from one kind of crop to another; and there

would want to be some idle plots, so to say, upon which the sewage could be thrown at seasons when it was in excess of what the growing or maturing crops required. The reader will understand that in the process of irrigation a certain portion of the fluid will settle into the ground; and it is desirable that the ground should be of such a free and open character as to admit of this and to encourage it; for it is this earthy filtration supplementing the action of roots of the growing crops which deprives the sewage of its noxious qualities, and renders what is left of it fit to escape into the neighboring brook or stream. If this character of ground is not present, if the irrigation field has a heavy or clayey soil, deep drainage will enable it to produce the same cleansing effects; but the ground must be high enough to admit of this drainage-water, thus purified, escaping freely into some neighboring stream. To this, the most favorable view of irrigation as a means of entire purification, there are two exceptions, and under a negligent manipulation of the process there would be more; these are, first, the storm waters, which at certain times will make the delivery through the sewers so large as to render any reasonable extent of irrigation-fields incompetent for the time being to meet the excess, which cannot be allowed to flood the field, but must be otherwise taken care of; the second exception is the winter, when for some months, it may be, the irrigation-fields will become useless as such. Beginning with what can be done, the difficulties which these exceptions present will gradually solve themselves, and it would be needless now to speculate upon the precise way in which this will be accomplished.

Dr. Folsom's report of how this has been met in Northern Europe will throw some light on the matter. When a beginning is made, however imperfectly, the necessities of the case will create the ambition to remedy what is amiss or incomplete, and some satisfactory solution of this difficult problem will in all probability follow.

It will be thought by some that in the winter the sewer-fluids might be passed into the stream without rendering its waters so objectionable as in summer; but the reverse is said to be the case: the gases which escape from the sewer-deposits in summer from over the entire surface of the stream

are sealed up in winter, so that by breaking a hole in the ice the bad odor is made perceptible by this kind of concentration in winter, when in summer the sense of smell does not reach it under ordinary circumstances. The winter water is therefore more dangerous than the summer water except that, there being generally more water flowing in the river then, the poisonous fluids entering it will be more diluted,

It is probably true that no process or combination of processes for the sufficient purification of sewage-waters has ever produced results which collectively made it remunerative; the precipitate collected by most of the patent processes will always sell for something for farming purposes, and where irrigation is used besides, crops will be large and have commanded good prices, but the adjuncts (whether of land for filtration or otherwise) necessary to destroy the whole of the filth more than eat up the profits. It is a great advantage and encouragement to be able to reduce the cost of this kind of purification; but to attain the desired result without any outlay, far less to make it a means of profit, is not, in the present state of our knowledge, to be expected.

The ground below Worcester is understood to be very favorably situated for irrigation, and the soil and subsoil to be of the right character as well for filtration. There will be a good opportunity, then, to deliver the Blackstone River from this its greatest concentration of pollution, and to experiment on the kinds of winter appliances that will be necessary in combination either with irrigation or filtration.

DRAINAGE AND SEWERAGE.

We come now to the second branch of the subject in the order in which it has been presented here, although in the discussion of the first it has been impossible to avoid touching on the second.

The law requires the Board of Health "to investigate the subject of the correct method of drainage and sewerage of the cities and towns of the Commonwealth, and to devise and report a system by which said cities and towns may be properly drained."

To devise a system which, within the compass of a report of this kind would be applicable in its details to all cities and

towns, would be impossible; every city or town must be the subject of a separate study by a competent engineer, founded on a correct and minute survey of the streets or ground to be drained or sewerred, with correct levellings of the whole.

The law evidently did not intend this construction to be put upon it, but it may have expected that some general principles should be presented controlling this part of the subject. Such general principles will govern each case, but to prescribe any special mode of carrying them out might be burdensome where all the State is interested in the result. Some points, however, may be noticed that are independent of any particular working system, or common to all of them.

In Europe, the drainage of the subsoil by a separate provision of drains, apart from the usual system of sewers to carry off the house-refuse, has been advocated, and there may be places where from the character of the subsoil or the amount of water present in it, such a double system would be desirable; but it has not found favor in this country, nor are we aware that it has been anywhere found necessary; * the increased cost of any such double system, and the inconvenience to the streets growing out of its proper maintenance, would always be barriers to its adoption.

The proper drainage of the soil is always very important, but, except where the water is held up by a neighboring river or lake or by tide-water, the trenches made for the sewers in our cities evidently act more or less as blind drains to keep it down.

This drainage of the subsoil, following as it frequently does the construction of sewers, if obtained at all through that defective construction which admits of leakage *into* the sewers, will do no harm while that leakage is moderate in amount, and consists of subsoil water escaping *into* the sewers. But the engineer will note that the same defective construction would admit of leakage from the sewer into the subsoil, when the subsoil-water happened to get below the level of the sewer, and that in this case the evil following a leakage outward would be twofold: the subsoil would be rendered filthy and might infect the neighboring cellars, and the

* It has been used for some years in three towns of England.

fluid necessary to the flow of sewage-matters, if lost in this way, would lead to deposits within the sewers of the heavier matters, very objectionable there in every way.

For the continued and perfect action of the sewage, therefore, under all circumstances, the sewer should be so constructed as to be tight, and not leaky, unless the circumstances make the other course very clearly desirable. It is not difficult to make concrete sewers tight, if made with Portland cement concrete, or its equal; nor is it difficult, with proper attention to the joints, to make a pipe-sewer tight, nor a brick sewer, if the engineer is determined to have it so.

The neglect of deep-soil drainage in the country at farm-houses, isolated dwellings of any kind, or villages, must be the cause of more sickness than any defects in the condition of the waters used there. In cities, the sewer-drains, or trenches, which are always deep, to some extent take care of it, and, where they do not, the damp or wet cellars make the danger known, and show the necessity then of some separate provision to keep down the subsoil water. In those streets of a city which lie on a river bank, subject to floods, or upon the seaboard, as Boston, where the tides rise from eight to ten feet, both the drainage and the sewerage, as ordinarily provided for, are liable to serious interruption; in the first case, irregularly; in the second case, daily. To provide, if possible, for the uninterrupted flow of the sewage, is always important. It is very important that that flow should not at any time be brought to rest, because then the heavier portions will become deposited, and will accumulate and fester so as to generate the dangerous gases which belong to putrid sewage, but which in the case of fresh sewage are merely offensive. It is desirable always that the sewage generated in a city should leave the city on the same day, within twelve hours at most, and that it should never be retained long enough to become putrid. The drainage in such exceptional cases would be a more difficult matter, and it would probably be cheaper in most cases to keep all streets and dwellings situated well up above tidal influences, than to attempt to keep down the subsoil water. But the interruption of the sewage-flow is another matter; it leads to a filthy deposit growing with each day, and which cannot be removed by the

rate of original flow which would have kept it in motion to the pump-wells, and prevented its deposit. If it is allowed to subside and get firm, it can only be carried off thereafter at intervals by storm waters, or by flushing, or by manual labor; in either case after it has become very offensive. Under such a state of things, ventilation becomes very important. It is conceded that the impure air of sewers should rather be allowed by frequent shafts to escape into the street, than be driven into the houses, as it will be more or less, if no other *outlet* is provided for it.

Of the sewage proper, the Board of Health is required "to report how far said sewage may be utilized and disposed of."

The utilization of sewage by irrigation has already been dwelt upon, and the auxiliary works which may have possibly to accompany irrigation wherever the intention is as well to render the sewage-fluid, or its residues innocuous.

The utilization separately of the precipitates from sewage has been and is in many patent ways accomplished, but the fluids are not entirely deprived of their baneful qualities, and are reported to be unfit to pass into a river. None of these processes are remunerative when the other condition of rendering the fluid residue sufficiently pure as well as clear is insisted on. It is to be remarked of all these precipitates from sewage that, except when mixed with lime or some other equally valuable ingredients, they are all but worthless for manure. To make them salable for agricultural purposes, they must be enriched with foreign ingredients, without which the offensive solids of the sewage could not be got rid of.

The attempt is being made in some places on the continent of Europe, with a good deal of success, to keep separate the human excrements, and not allow them to enter the sewers, withdrawing them separately from the houses while fresh, and in various ways preparing them for agricultural use. It is obvious that if this could be accomplished, the kitchen fluids, the trades and the street refuse would be somewhat more easily and more willingly dealt with. The human refuse, although trifling in *degree*, compared with the mass of fluid which flows through a sewer, is yet sufficient to give it much of its offensive character, and to produce, when the sewers are neglected, many of the offensive odors and gases that are

believed to be dangerous to health. The separate mode of disposing of human excrement is, however, repugnant to our habits here, and therefore, both here and in Great Britain, the water-closets and the removal by water of all human refuse is greatly preferred.

The most successful modes of dealing with sewage at this date, as well as with other pollutions which at present are rendering the waters of our streams so objectionable, are explained in the separate report of Dr. Folsom, who has devoted the past season to an examination of such operations in Europe. When it shall be necessary to act, we have thus the benefit of a large and varied European experience. Much of it can doubtless be assimilated here, with such additions or modifications as will meet the rigor of our winter climate.

The following skeleton maps are submitted with this statement, showing the streams of the five valleys examined, and also the positions of the dams and factories on these streams, viz. :—

The Chicopee River Valley.

The Blackstone “ “

The Neponset “ “

The Charles “ “

The Taunton “ “

Also an index map, giving on a small scale the principal river-valleys in the State.

TABLES OF ANALYSES:

WITH REMARKS ON THE WATERS OF THE DIFFERENT VALLEYS.

By Prof. WM. RIPLEY NICHOLS.

CHEMICAL LABORATORY OF THE MASS. INSTITUTE OF TECHNOLOGY, }
BOSTON, January, 1876. }

JAMES P. KIRKWOOD, Esq.

DEAR SIR:—Allow me to present herewith the report of the chemical examinations of the various samples of water sent to me by your assistants.

As a rule, the waters were allowed to stand for some twelve hours, in order that any matter in suspension might be deposited. The clear water was then drawn off for the determination of the solid residue. The determinations of "ammonia," "albuminoid ammonia" and "oxygen required to oxidize organic matter," were made after the water had been filtered through filter-paper. Owing to the unavoidable irregularity of the delivery of the specimens by the various express companies, and to the occasional interruption by Sundays, it was impossible that the different samples should be examined at the same length of time after their collection.

WATER FROM THE CHICOPEE VALLEY.

[See Table I.]

All the specimens of water from the Chicopee Valley were somewhat alkaline, and no case was observed where any refuse of any acid character had been thrown into the streams in sufficient quantity to alter the alkaline character of the water.

All the specimens were more or less colored by vegetable matter in solution. All deposited, on standing, a slight sediment containing vegetable matter, partly in combination with iron. There was not enough sediment in any case to make its determination seem of any practical moment.

The samples from the Connecticut River (Nos. 11 and 12) were less strongly colored, and possessed a more marked alkaline reaction. They contained a larger proportion of mineral matter, as appears from the table.

WATER FROM THE BLACKSTONE VALLEY.

[See Table II.]

The waters were all alkaline. As a rule, they were not as strongly colored as those from the Chicopee, Taunton, etc. The samples taken from the upper part of the river showed evidence of considerable sewage-contamination. Some of them contained a marked amount of suspended matter, which amount was determined in a few cases. A disagreeable odor was also perceptible in some of the specimens.

WATER FROM THE NEPONSET VALLEY.

The results of the chemical examination are presented in Table III.

The waters are all slightly alkaline, are somewhat colored, and deposit a trifling sediment when allowed to stand quietly.

WATER FROM THE TAUNTON VALLEY.

[See Table IV.]

The water of the great ponds (such as Assawampsett, Great Quittacas and Little Quittacas), and of some of the brooks at the head-waters of the Taunton River, is clear, and nearly colorless. The water of the river itself and of its main tributaries is quite strongly colored with vegetable matter, probably, in part, at least, combined with iron, which occurs to a greater amount in the waters of this stream than in that of some of the others examined.

The waters, like those of most rivers, are slightly alkaline, less so as a rule than those of the Chicopee or Blackstone, and much less so than the Connecticut, at Springfield. On two occasions only have I observed other than an alkaline reaction. Samples of water were taken at two different times at East Taunton, *above* and *below* the Old Colony Iron Works. The sample taken August 6, below the works, was slightly but distinctly *acid*. The other occasion was August

5, when specimens were taken above and below the Bridge-water Iron Works. The specimen taken *above* the works was slightly alkaline; that taken *below* was neutral—neither acid nor alkaline. This would seem to indicate that at times a small amount of acid liquor of some sort is allowed to run into the river.

The only specimen polluted to any considerable extent was No. 39, taken below a wool-scouring establishment. This specimen was very turbid, and did not become clear on standing. The greasy-looking suspended matter was seen under the microscope to contain bits of animal hair (wool) and epithelial cells, besides animal and vegetable microscopic growth. The tables show that the influence of the salt water is felt above the entrance of Three Mile River, but not so far as the entrance of Little River (Mill River); also, I think the tide has no influence on the water at "Shallow Water," from which point it is proposed to take the water-supply of the city of Taunton, the differences between samples taken at different states of the tide not following any regular law. I think the examination further shows that, while undoubtedly the most desirable water-supply for the city of Taunton is offered in the great ponds, yet the river is able to afford water sufficiently and practically pure for domestic purposes, and superior to most, if not all, the water at present derived from wells.

WATER FROM THE CHARLES RIVER.

[See Table V.]

The waters presented no marked peculiarity. They contained only a trifling amount of matter in suspension, and were not colored to a great extent.

TABLE I.—*Analyses of Samples of Water from the Blackstone Valley, July and September, 1875. Collected by E. K. CLARK.*
 [Results expressed in Parts per 100,000.]

Number.	Date of Collection.	LOCALITY.	Date of Examination.	Ammonia.	"Albuminoid Am- monia."	Solid Residue.			Chlorine.	Oxygen required to ox- idize organic matter.	Letter on Map show- ing where sample was taken.	Name of water from which sample was taken.
						Inorganic.	Organic and Vol- atile.	Total at 212 deg. Fahr.				
a 1,	July 7, 4.30 P. M.,	Canal above Blackstone Mills, ...	July 10,	0.0093	0.0150	3.44	1.72	5.16	0.38	0.371	a	Blackstone River.
b 2,	July 7, 5 P. M.,	} Below Blackstone Mills,	10,	0.0099	0.0139	3.16	1.64	4.80	0.38	0.438	b	"
c 3,	July 8, 9.20 A. M.,	} Below dam at Black- stone, ...	10,	0.0157	0.0163	3.20	1.40	4.60	0.36	0.356	c	"
d 4,	July 8, 11.30 A. M.,	} Below dam at Millville,	10,	0.0168	0.0181	3.28	1.36	4.64	0.38	0.331	d	"
e 5,	July 8, 6.30 P. M.,	} Blackstone River, below junc. with West Riv.,	12,	0.0048	0.0152	2.00	1.92	3.92	0.24	0.400	e	"
f 6,	July 8, 7.30 P. M.,	} Blackstone, near state line, ...	12,	0.0114	0.0128	2.68	1.72	4.40	0.32	0.326	f	"
g 7,	July 9, 11.20 A. M.,	} West River, in Upton, .	13,	0.0128	0.0160	2.24	1.72	3.96	0.22	0.429	g	West River.
h 8,	July 9, 4.30 P. M.,	} West River, below Wheelock's Mills, . .	13,	0.0088	0.0133	2.40	1.40	3.80	0.24	0.392	h	"
i 9,	July 14, 4 P. M.,	} Mumford R., near junc. with Blackstone, . .	16,	0.0091	0.0128	2.08	1.28	3.36	0.22	0.333	i	Mumford River.
j 10,	July 14,	} Below Rockdale Mills, Northbridge, ...	16,	0.0093	0.0155	3.20	1.88	5.08	0.48	0.279	j	Blackstone River.

k 11,	July 14, 10.45 A. M.,	Blackstone River, below Farmville,	17,	0.0155	0.0160	4.24	2.36	6.60	0.54	0.326	k	Blackstone River.
1 12,	July 14, 12 M.,	Blackstone River, below Fisher's Mill,	17,	0.0112	0.0173	3.68	2.16	5.84	0.54	0.299	l	"
13,	July 19, 11 A. M.,	Same as No. 12,	20,	0.0128	0.0160	4.12	2.08	6.20	0.50	0.321	l	Blackstone River.
m 14,	July 19, 11.40 A. M.,	Quinsigamond R., $\frac{1}{4}$ mile above junction,	20,	0.0053	0.0155	1.60	2.20	3.80	0.18	0.318	m	Quinsigamond River.
15,	July 19,	{ Trench below Simpson's Mill, on Blackstone R., ²	22,	0.0293	0.0181	4.64	2.56	7.20	0.74	0.439	n	Blackstone River.
o 16,	July 20, 10.10 A. M.,	Above Millbury cotton mill, ³	22,	0.0560	0.0299	5.40	2.96	8.36	0.92	0.467	o	"
18,	July 21, 2 P. M.,	Same, ³	22,	0.0325	0.0327	4.92	2.96	7.88	0.66	0.470	o	"
23,	July 22, 2.45 P. M.,	Same, ³	23,	0.0288	0.0303	4.12	2.68	6.80	0.66	0.520	o	"
27,	July 29, 9.30 A. M.,	Same, ³	31,	0.0197	0.0213	4.88	2.40	7.28	0.74	-	o	"
p 17,	July 20,	{ Morse's Sash and Blind Factory on Blackstone River, ²	22,	0.0992	0.0307	4.84	3.20	8.04	0.92	0.429	p	"
24,	July 22, 3 P. M.,	Same,	23,	0.0661	0.0272	4.56	2.32	6.88	0.72	0.518	p	"
29,	July 29, 2 P. M.,	Same,	31,	0.0597	0.0272	4.64	2.12	6.76	0.72	0.527	p	"
q 19,	July 21, 2 P. M.,	Blackstone R., $\frac{1}{4}$ mile be- low Burling Mills, ⁴	22,	0.0640	0.0224	4.18	2.92	7.00	0.68	0.453	q	"
r 20,	July 21,	{ Stone Bridge, below Quinsigamond Vill., ⁵	22,	0.0672	0.0256	3.96	2.84	6.80	0.66	0.438	r	"

³ Develops bad odor on standing.

² Some odor.

¹ Rather more suspended matter than in Nos. 1-9.

⁴ More iron apparently than in the preceding specimens. Considerable suspended matter.

⁵ Suspended matter: Inorganic, 1.19; organic, 0.23; total, 1.42. Considerable iron in residue.

Analyses of Samples of Water from the Blackstone Valley — Continued.

Number.	Date of Collection.	LOCALITY.	Date of Examination.	Ammonia.	"Albuminoid Ammonia."	SOLID RESIDUE.			Chlorine.	Oxygen required to oxidize organic matter.	Letter on Map showing where sample was taken.	Name of water from which sample was taken.
						Inorganic.	Organic and Volatile.	Total at 212 deg. Fahr.				
s 21,	July 22, 9.30 A. M.,	Just above Quinsigamond Iron Works, Worcester, ¹	July 23,	0.1866	0.0320	6.72	3.52	10.24	1.36	0.549	s	Blackstone River.
t 22,	July 22,	{ Singletary Stream, near Blackstone River, ²	23,	0.0107	0.0299	3.20	3.56	6.76	0.22	0.544	t	Singletary Stream.
28,	July 20,	Same,	31,	0.0149	0.0309	3.32	3.00	6.32	0.26	0.568	t	"
u 25,	July 21, 12.30 P. M.,	{ Kettle Brook at Thayer's Mill,	22,	0.0149	0.0181	1.52	1.56	3.08	0.16	0.406	u	Kettle Brook.
v 26,	July 21, 5.30 P. M.,	{ Mill Brook above Washburn & Moen Manuf. Co.'s Works,	22,	0.0123	0.0181	2.60	1.32	3.92	0.24	0.416	v	Mill Brook.
w 31,	July 29, 11 A. M.,	{ Trench leading to Bur-ling Mills,	31,	0.0768	0.0283	4.36	1.92	6.28	0.64	0.490	w	Blackstone River.
x 32,	July 29,	{ Mill Brook, near Blackstone River, ³	31,	0.9600	0.1109	18.48	4.96	23.44	3.80	1.098	x	Mill Brook.
y 33,	-	-	-	-	-	-	-	-	-	-	y	Kettle Brook.
34,	?	{ Blackstone River, above dam of Uxbridge Woolen Mill,	Aug. 11,	0.0075	0.0160	3.72	2.12	5.84	0.60	0.386	z	Blackstone River.
35,	?	{ Trench below Fisher's Mill, Blackstone Riv.,	11,	0.0112	0.0193	4.04	2.64	6.68	0.61	0.504	aa	"

42,	Sept. 10, 6.30 P. M.,	Weasel Brook, one mile above North Pond, .	Sept. 15,	0.0067	0.0200	3.32	1.68	5.00	0.14	0.448	c'	Weasel Brook.
43,	Sept. 10, 7 P. M.,	North Pond, . . .	14,	0.0107	0.0213	2.40	1.80	4.20	0.18	0.588	c''	North Pond.
44,	Sept. 11, 10.30 A. M.,	Bottomly Pond, . .	14,	0.0128	0.0280	1.88	1.56	3.44	0.16	0.698	c'''	Bottomly Pond.
45,	Sept. 11, 12 M.,	Tatnick Brook, above Sinclair's Mill, . .	14,	0.0091	0.0213	1.72	1.44	3.16	0.14	0.559	c''''	Tatnick Brook.
46,	Sept. 11, 2.30 P. M.,	Middle of Lake Quin- sigamond, . . .	14,	0.0037	0.0157	2.28	1.56	3.84	0.14	0.304	d'	Quinsigamond Lake.
47,	Sept. 14,	Lower part of Tatnick Brook, . . .	15,	0.0072	0.0187	2.56	1.68	4.24	0.20	0.354	d''	Tatnick Brook.
48,	Sept. 14, 3 P. M.,	Gate-house on Lynde Brook, City Reserv'r.,	15,	0.0072	0.0235	1.80	1.96	3.76	0.12	0.504	d'''	Lynde Brook.
49,	Sept. 15, 9 A. M.,	Singletary Pond, . .	15,	0.0176	0.0181	2.00	1.16	3.16	0.16	0.193	d''''	Singletary Pond.
50,	Sept. 14, 10 A. M.,	Manchaug Pond, . .	15,	0.0080	0.0181	1.72	0.96	2.68	0.16	0.236	e'	Manchaug Pond.
51,	Sept. -,	Lower end of Douglas Reservoir (source of Mumford River), .	18,	0.0048	0.0149	1.36	0.88	2.24	0.14	0.323	e''	Douglas Reservoir.
52,	Sept. -,	Singletary Brook, near Blackstone R. (same as Nos. 22 and 28), .	18,	0.0123	0.0381	3.20	3.00	6.20	0.26	0.599	t	Singletary Brook.

¹ Suspended matter :—Inorganic, 0.75; organic, 0.62; total, 1.37. Odor of sewage. Considerable iron in residue.

² Slight odor. Somewhat turbid. Not colored yellow, as the water of the Blackstone is to some extent.

³ Quite turbid. Foul odor. Suspended matter :—Inorganic, 1.80; organic, 2.95; total, 4.75.

⁴ Denijohn broken in transit.

TABLE II.—*Analyses of Samples of Water from Neponset Valley, July and August, 1875. Collected by C. D. Ward.*
 [Results expressed in Parts per 100,000.]

Number.	Date of Collection.	LOCALITY.	Date of Examination.	Ammonia.	"Albuminoid Ammonia."	SOLID RESIDUE.			Chlorine.	Oxygen required to oxidize organic matter.	Letter on Map showing where sample was taken.	Name of water from which sample was taken.
						Inorganic.	Organic and Volatile.	Total at 212 deg. Fahr.				
1.	July 27,	{ Between South Canton and Dedham, . }	July 31, Aug.	0.0080	0.0160	2.32	1.96	4.28	0.36	0.694	C	Neponset River.
15.	August 6,	Same, ...	9.	0.0085	0.0192	3.00	2.04	5.04	0.50	0.725	"	"
2.	July 27,	{ S. Dedham, at 1st bridge above ink-works, }	July 31, Aug.	0.0080	0.0165	3.16	1.88	5.04	0.39	0.648	c ¹	"
16.	August 6,	Same, ...	9.	0.0075	0.0149	2.76	2.12	4.88	0.36	0.664	"	"
3.	July 28,	{ Walpole, at bridge on di- rect road to S. Dedham, }	July 30, Aug.	0.0040	0.0261	3.08	2.48	5.56	0.42	0.752	c ²	"
17.	August 6,	Same, ...	9.	0.0052	0.0171	2.28	2.76	5.04	0.38	1.165	"	"
4.	July 28,	{ So. Walpole, above all pollution, . . . }	July 30, Aug.	0.0091	0.0325	1.88	2.52	4.40	0.28	0.790	d	"
18.	August 6,	Same, ...	9.	0.0085	0.0176	1.84	1.92	3.76	0.27	0.792	"	"

5, .	July 29,	{ Milton Lower Mills, } above Baker's dam, . }	July 30,	0.0101	0.0181	2.88	2.28	5.16	0.44	0.666	A	Neponset River.
10, .	August 6,	Same, ...	Aug. 7,	0.0123	0.0160	3.40	2.16	5.56	0.48	0.668	"	"
6, .	July 29,	{ Below Hyde Park, at R. } R. bridge, B. H. & E. }	July 30,	0.0107	0.0261	2.68	2.60	5.28	0.43	0.637	a ¹	"
11, .	August 6,	Same, ...	Aug. 7,	0.0101	0.0155	2.88	2.40	5.28	0.48	0.664	"	"
7, .	July 29,	{ Mother Brook, Hyde } Park, 1st bridge above }	July 30,	0.0181	0.0181	2.56	2.64	5.20	0.34	0.774	a ²	Mother Brook.
12, .	August 6,	Same, ...	Aug. 9,	0.0133	0.0176	2.48	2.16	4.64	0.37	0.516	"	"
8, .	July 29,	{ Neponset River, $\frac{1}{8}$ mile } above junction with }	July 30,	0.0091	0.0203	2.80	2.32	5.12	0.45	0.709	B	Neponset River.
13, .	August 6,	Same, ...	Aug. 9,	0.0080	0.0197	3.12	1.92	5.04	0.51	0.684	"	"
9, .	July 29,	{ Above all mills on } Mother Brook, . . }	July 31,	0.0043	0.0155	2.44	1.84	4.28	0.32	0.565	a ³	Mother Brook.
14, .	August 6,	Same, ...	Aug. 9,	0.0069	0.0171	2.52	1.88	4.40	0.34	0.513	"	"

TABLE III.—*Analyses of Samples of Water from the Charles River Valley, August and October, 1875.*

[Results expressed in Parts per 100,000.]

Number.	Date of Collection.	LOCALITY.	Date of Examination.	Ammonia.	"Albuminoid Ammonia."	SOLID RESIDUE.			Chlorine.	Oxygen required to oxidize organic matter.	Letter on Map showing where sample was taken.	Name of water from which sample was taken.
						Inorganic.	Organic and Volatile.	Total at 212 deg. Fahr.				
36, . {	Aug. 21, 11 A. M.,	Below Bellingham paper mill, Medway, .	Aug. 26,	0.0128	0.0229	2.72	2.32	5.04	0.40	0.635	a	Charles River.
37, . {	Aug. 24, 10.45 A. M.,	Medway Village, below grist and shoddy mill,	26,	0.0123	0.0235	3.24	2.88	6.12	0.51	0.845	b	"
38, . {	Aug. 24, 2 P. M.,	Below Bellingham wool-en mill, . . .	26,	0.0059	0.0299	3.20	3.00	6.20	0.35	0.990	c	"
39, .	Aug. 24,	{ Below paint mill, on Wauban Brook, . .	26,	0.0032	0.0155	2.68	2.20	4.88	0.24	0.410	d	Wauban Brook.
40, .	Aug. 31,	{ Above Newton Upper Falls, ...	Sept. 1,	0.0080	0.0293	2.68	2.92	5.60	0.40	1.043	e	Charles River.
41, . {	Aug. 31, 2 P. M.,	At Dedham, above stone bridge, ...	1,	0.0096	0.0328	2.72	2.72	5.44	0.36	0.868	f	"
55, . {	Oct. 1, 3 P. M.,	East Holliston Pond, .	Oct. 4,	0.0083	0.0208	2.44	1.48	3.92	0.36	-	g	East Holliston Pond. ¹

56, .	-	{ Cedar Swamp Pond, } Milford, ...	4, 0.0080	0.0272	2.24	2.20	4.44	0.41	-	h	Cedar Swamp Pond. ¹
57, . {	Oct. 1, 10 A. M.,	{ Whiting Pond, Wren- } tham, ...	4, 0.0059	0.0107	2.16	0.84	3.00	0.28	-	i	Whiting Pond. ¹
58, .	-	{ Reservoir, head of Stop } River, ...	4, 0.0085	0.0091	2.80	0.96	3.76	0.28	-	j	{ Reservoir, head of Stop River.
59, . {	Oct. 1, 8 A. M.,	{ Charles River, below } junction of Mill Riv.,	4, 0.0069	0.0187	3.16	1.48	4.64	0.48	-	k	Charles River.

¹ No pollution.

d ¹ 4,	July 8, 1.15 P. M.,	Ware River, 500 feet below Barre Falls, . . .	July 10,	0.0080	0.0219	2.12	2.88	5.00	0.14	-	-
20,	Aug. 9,	Same, . . .	Aug. 11,	0.0075	0.0227	2.76	2.96	5.72	0.16	1.606	-
d ³ 5,	July 9, 10 A. M.,	Middle Branch of Swift River, at North Dana . . .	July 12,	0.0080	0.0110	2.16	1.32	3.48	0.14	0.282	-
d ³ 13,	July 22,	Same, . . .	24,	0.0053	0.0128	1.64	1.88	3.52	0.08	0.432	-
³ C 6,	July 9, 12 M.,	Swift River, below En- field, Hampshire Co., . . .	12,	0.0128	0.0160	2.40	2.04	4.44	0.12	0.542	-
14,	July 22,	Same, . . .	24,	0.0093	0.0165	2.28	2.16	4.44	0.09	0.536	-
B 7,	July 9, 6 P. M.,	Chicopee R., $\frac{1}{2}$ mile below Palmer Cotton Mills, . . .	12,	0.0112	0.0144	2.24	2.20	4.44	0.14	0.514	-
15,	July 22,	Same, . . .	24,	0.0064	0.0115	2.48	2.32	4.80	0.11	0.508	-
a ¹ 8,	July 10, 9.15 A. M.,	Chicopee R., $\frac{1}{2}$ mile below Chicopee Falls, . . .	12	0.0091	0.0147	2.72	1.48	4.20	0.12	0.483	-
10,	July 21,	Same, . . .	24,	0.0096	0.0128	3.32	2.32	5.64	0.14	0.462	-
A 9,	July 10, 10.15 A. M.,	Chicopee R., at dam of Dwight Manuf'g Co., . . .	12,	0.0112	0.0155	3.00	2.08	5.08	0.12	0.498	-
11,	July 21,	Chicopee Centre, Connecticut R., opposite upper part of Spring ¹ ld., . . .	24,	0.0085	0.0128	4.64	1.64	6.28	0.09	0.394	Taken 1-3 across from west bank.
12,	July 21,	Same, . . .	24,	0.0085	0.0139	4.44	1.68	6.12	0.09	0.393	Taken 1-3 across from east bank.

TABLE V.—*Analyses of Samples of Water from the Taunton River Valley, July and August, 1875.* Collected by F. L. FULLER.
 [Results expressed in Parts per 100,000.]

Number.	Date of Collection.	LOCALITY.	Date of Examination.	Ammonia.	"Albuminoid Ammonia."	SOLID RESIDUE.			Chlorine.	Oxygen required to oxidize organic matter.	Letter on Map showing where sample was taken.	Name of water from which sample was taken.
						Inorganic.	Organic and Volatile.	Total at 212 deg. Fahr.				
1, {	July 28, 6.30 A. M.,	Stream from Forge Pond, Raynham, .	July 29,	0.0059	0.0245	2.48	3.00	5.48	0.34	1.486	r	{ Dead Swamp Brook or Two Mile Riv.
2, {	July 28, 11.20 A. M.,	Taunton River, just below junction with Little River, .	29,	0.0067	0.0240	2.80	2.32	5.12	0.34	0.998	i ₁	Taunton River.
6, {	July 28, 6.15 P. M.,	Same, ...	30,	0.0203	0.0181	2.84	2.16	5.00	0.35	1.050	i ₂	" "
3, {	July 28, 11.40 A. M.,	{ Little (or Mill) River, just before joining Taunton River, .	29,	0.0123	0.0245	2.68	2.24	4.92	0.33	0.787	j ₁	Little (or Mill) Riv.
34, {	Aug. 10, 5.10 P. M.,		Aug. 14,	0.0176	0.0176	2.68	3.20	5.88	0.37	0.878	j ₂	" "
35, {	Aug. 11, 11.15 A. M.,		14,	0.0091	0.0171	2.20	2.68	4.88	0.33	0.783	j ₃	" "
4, {	July 28, 11.50 A. M.,	{ Taunton River, just above junction with Little (or Mill) Riv.,	July 29,	0.0043	0.0235	2.44	2.92	5.36	0.39	1.124	o ₁	Taunton River.
7, {	July 28, 6.40 P. M.,		30,	0.0096	0.0197	2.68	2.72	5.40	0.39	1.349	o ₂	" "

5, { July 28, 5.30 P. M., Aug. 10, 4.20 P. M., 33, {	Taunton River, at "Shal- low Water," taken at { high tide, . . .	July 30, Aug. 14,	0.0080	0.0208	3.08	2.56	5.64	0.40	1.488	q ₁	Taunton River.
T 1, April,	Mean of last three, .	Apr. 23,	0.0067	0.0363	1.32	2.20	3.52	0.35	—	q ₂	"
		.	0.0077	0.0256	2.32	3.00	5.32	0.38	1.559		"
13, { July 30, 4.15 P. M., Aug. 10, 11.25 A. M., 32, {	Taunton River, at "Shal- low Water," taken at { low tide, . . .	Aug. 2, 14,	0.0048	0.0192	2.88	2.56	5.44	0.40	1.460	q ₃	Taunton River.
T 15, May,	Mean of last three, .	May 4,	0.0007	0.0180	2.53	2.04	4.57	0.42	—	q ₄	"
			0.0047	0.0184	2.58	2.84	5.42	0.41	1.587		"
8, { July 29, 9.50 A. M.,	Little River, above dam of D. C. M. Mfg. Co.,	July 30,	0.0176	0.0176	2.84	1.68	4.52	0.27	0.902	k	Little (or Mill) Riv.
9, { July 29, 10.45 A. M.,	Scadding's Pond, . .	30,	0.0091	0.0192	1.64	1.68	3.32	0.26	0.937	l	Scadding's Pond.
10, { July 29, 11.20 A. M.,	Prospect Pond, . .	30,	0.0112	0.0165	1.76	3.00	4.76	0.32	0.885	s	Prospect Pond.

* This determination was made for the city of Taunton.

Analyses of Samples of Water from the Taunton River Valley — Continued.

Number.	Date of Collection.	LOCALITY.	Date of Examination.	Ammonia.	"Albuminoid Ammonia."	SOLID RESIDUE.			Chlorine.	Oxygen required to oxidize organic matter.	Letter on Map showing where sample was taken.	Name of water from which sample was taken.
						Inorganic.	Organic and Volatile.	Total at 212 deg. Fahr.				
11, { 27, {	July 30, 11.30 A. M., Aug. 6, 10.50 A. M.,	{ East Taunton, above Old Col. Iron Works, . Mean of last two, .	Aug. 2, 11, .	0.0053 0.0069 0.0061	0.0203 0.0171 0.0187	2.40 2.80 2.60	2.64 2.36 2.50	5.04 5.16 5.10	0.38 0.40 0.39	1.323 1.228 1.276	u ₁ u ₂	Taunton River. "
12, { 26, {	July 30, 11.50 A. M., Aug. 6, 10 A. M.,	{ East Taunton, below Old Col. Iron Works, . Mean of last two, .	Aug. 2, 9, .	0.0069 0.0080 0.0075	0.0235 0.0187 0.0211	2.76 2.76 2.76	2.56 2.24 2.40	5.32 5.00 5.16	0.42 0.44 0.43	1.359 1.074 1.216	t ₁ t ₂	Taunton River. "
14, { 15, {	July 31, 7 A. M., Aug. 4, 10.45 A. M.,	{ Taunton River at upper br. O. C. & N. R. R., . { Three Mile River, just before it joins the Taunton, . . .	Aug. 2, 6, .	0.0053 0.0080	0.0175 0.0181	2.76 2.44	2.64 1.96	5.40 4.40	0.40 0.32	1.420 0.713	p b	Taunton River.* Three-mile River.†

16, {	Aug. 4, 11 A. M.,	{ Taunton River, 700 feet above entrance of Three Mile River, }	6,	0.0085	0.0160	4.28	2.44	6.72	1.06	1.004	h	Taunton River.†
17, {	Aug. 4, 11.15 A. M.,	{ Taunton River, 600 feet below junction with Three Mile River, }	6,	0.0085	0.0197	11.68	4.32	16.90	5.50	1.012	a	Taunton River.†
18, {	Aug. 4, 2.35 P. M.,	{ Three Mile River, below Oakland Cotton Mill, }	6,	0.0064	0.0187	2.88	2.20	5.08	0.26	0.963	c	Three Mile River.
19, {	Aug. 4, 4 P. M.,	{ Three Mile River, above Crocker's Dam, Nor- ton, . . . }	6,	0.0085	0.0181	2.16	1.84	4.00	0.26	0.785	d	Three Mile River.
20, {	Aug. 5, 12 M.,	{ Nippenicket Pond, . }	7,	0.0096	0.0240	2.52	2.80	5.32	0.28	1.369	e¹	Nippenicket Pond.
21, {	Aug. 5, 2 P. M.,	{ Town R., above Bridge- water Iron Works, }	7,	0.0096	0.0224	2.88	3.20	6.08	0.30	1.533	d¹	Town River.
22, {	Aug. 5, 2.20 P. M.,	{ Town R., below the iron- works, . . . }	7,	0.0075	0.0211	-	-	6.16	0.31	1.608	e¹	" "
23, {	Aug. 5, 4.40 P. M.,	{ Taunton River, below Bridgew'r Paper Mill, }	7,	0.0123	0.0203	2.96	3.08	6.04	0.45	1.375	b¹	Taunton River.
24, {	Aug. 5, 5.40 P. M.,	{ Winetuxet R., Thomp- son's Bridge, . . }	7,	0.0091	0.0229	3.84	3.80	7.64	0.46	-	a¹	Winetuxet River.

† High water.

* Tide running up.

Analyses of Samples of Water from the Taunton River Valley -- Concluded.

Number.	Date of Collection.	LOCALITY.	Date of Examination.	Ammonia.	"Albuminoid Ammonia."	Solid Residue.			Chlorine.	Oxygen required to oxidize organic matter.	Letter on Map showing where sample was taken.	Name of water from which sample was taken.
						Inorganic.	Organic and Volatile.	Total at 212 deg. Fahr.				
25, {	Aug. 5, 6 P. M.,	Namasket R., just before it joins the Taunton, . }	Aug. 7,	0.0058	0.0144	2.24	2.24	4.48	0.39	0.961	v	Namasket River.
28, {	Aug. 6, 1.10 P. M.,	} Assowompset Pond, . }	11,	0.0059	0.0128	1.72	1.28	3.00	0.37	0.536	w	Assowompset Pond.
29, {	Aug. 6, 1.30 P. M.,	} Stream connecting Long & Assowompset ponds, }	11,	0.0064	0.0155	1.84	1.68	3.52	0.36	0.824	x	{ Stream from Long to Assowomp't ponds.
30, {	Aug. 6, 2.40 P. M.,	} Little Quittacas Pond, . }	11,	0.0064	0.0096	1.76	1.24	3.00	0.39	0.440	z	Little Quittacas Pond.
31, {	Aug. 6, 4.15 P. M.,	} Great Quittacas Pond, . }	11,	0.0069	0.0133	1.96	1.44	3.40	0.40	0.577	y	Great Quittacas Pond.
36, {	Aug. 13, 4 P. M.,	Rumford River, Spring Street, Foxborough, . }	24,	0.0139	0.0133	2.24	2.04	4.28	0.24	0.705	f	Rumford River.
37, {	Aug. 13, 6.15 P. M.,	Canoe River, Willow Street, Foxborough, . }	24,	0.0155	0.0283	2.76	3.60	6.36	0.39	1.931	m	Canoe River.

38, {	Aug. 13, 6.30 P. M.,	Billings Brook, Cocasset Street, Foxborough, . }	Aug. 24,	0.0069	0.0080	2.24	1.24	3.48	0.26	0.423	g	Billings Brook.
39, {	Aug. 23, 9.30 A. M.,	Rumford R., below Nor- ton wool scour'g mill,* }	24,	0.0144	0.0293	3.80	5.48	9.28	0.39	0.970	e	Rumford River.
40, {	Aug. 17, ^e 12 M.,	Ames Pond, No. Easton, }	19,	0.0053	0.0165	2.08	1.28	3.36	0.27	0.427	g ¹	Ames Pond.
41, {	Aug. 17, 4.15 P. M.,	Massapoag Pond, . }	19,	0.0064	0.0144	1.36	2.28	3.64	0.27	0.388	-	In Neponset R. Val.
42, {	Aug. 17, 5.10 P. M.,	Stream from Leaches Pond, . . . }	19,	0.0043	0.0171	2.40	2.16	4.56	0.28	0.815	n	Leaches Stream.
43, {	Aug. 18, 7.20 A. M.,	Shovel Shop Pond, No. Easton, . . . }	19,	0.0080	0.0139	2.60	1.60	4.20	0.28	0.336	f ¹	Shovel Shop Pond.
44, {	Aug. 19, 12.30 P. M.,	Beaver Brook, above Young's dam, East Bridgewater, . . }	23,	0.0155	0.0256	2.68	2.60	5.28	0.40	1.349	h ¹	Beaver Brook.
45, {	Aug. 19, 3.30 P. M.,	Salisbury Brook, below Brockton Village, . }	23,	0.0155	0.0160	3.12	2.24	5.36	0.60	0.822	i ¹	Salisbury Brook.
46, {	Aug. 19, 5.50 P. M.,	Robbins Pond, E. Bridge- water, . . . }	23,	0.0128	0.0176	2.64	2.92	5.56	0.42	1.893	j ¹	Robbins Pond.
47, {	Aug. 20, 1.45 P. M.,	Monponset Pond, Hali- fax, . . . }	23,	0.0133	0.0171	2.40	2.36	4.76	0.44	1.198	k ¹	Monponset Pond.

* Suspended matter :—Inorganic, 4.37; organic, 5.97; total, 10.34.

METHODS OF ANALYSIS.

Total Solid Residue.—Except where the turbidity of the water rendered the determination of the suspended matter desirable, the waters were allowed to stand for from about twelve to eighteen hours, and the clear water taken for evaporation. The amount taken for evaporation was 250 c.c., and the residue was dried at 100° C. After ignition the residue was treated with an aqueous solution of carbonic acid, and again dried at 100°. This loss on ignition is tabulated, according to common custom, as “organic and volatile matter,” and is due in the main to the destruction of organic matter; the results thus obtained being sufficiently accurate for practical purposes, except when the water contains a considerable amount of nitrates and chlorides. In the case of well-water, not much value attaches to this means of determining the amount of organic matter.

Ammonia and “Albuminoid Ammonia.”—The ammonia existing ready formed in the water as free ammonia, or as carbonate, etc., is determined by distilling the water with carbonate of soda, and estimating the ammonia evolved, by means of Nessler’s reagent. A subsequent treatment with a strongly alkaline solution of permanganate of potash, as suggested by Messrs. Wanklyn, Chapman and Smith, causes the liberation of an additional amount of ammonia which is tabulated as “albuminoid ammonia” as it comes from the decomposition of albumin, or of other nitrogenous organic matter in some sense allied to albumin.

Chlorine.—The chlorine was determined volumetrically by means of a standard solution of nitrate of silver.

Oxygen required to oxidize Organic Matter, etc.—For the determination of organic matter by means of permanganate of potash, various methods have been proposed. I do not regard any method as giving absolute results. The method I have employed is that of Kubel, but I should regard the figures as relative, simply,—as affording additional data for the comparison with each other of the waters examined by the same person. No correction is made for the trifling amount of the permanganate which is, in these cases, used up in oxidizing any ferrous compounds.

II.—THE WATER-SUPPLY, DRAINAGE AND SEWERAGE OF THE STATE, FROM THE SANITARY POINT OF VIEW.

By FREDERICK WINSOR, M. D., of Winchester.

INTRODUCTION.

This investigation originated in the action taken at a meeting of the councillors of the Massachusetts Medical Society, held October 7, 1874, by which they referred the subject of a paper there read by Dr. R. Amory, of Brookline, (on "The Use of Running Streams as Sewers,") to a committee, consisting of Drs. Adams, Amory, Bowditch, Crowell, Hartwell and Hodgdon. At the next meeting of the councillors (February 3, 1875), this committee reported, recommending that a memorial to the general court be prepared in the name of the Massachusetts Medical Society, for the appointment of a commission to thoroughly investigate the subject. A resolution was passed adopting the recommendation. Such a memorial having been duly presented, the legislature passed a bill which, as finally amended, directed the State Board of Health to "investigate the subject of the correct method of drainage and sewerage of the cities and towns of the Commonwealth, especially with regard to the pollution of rivers," etc., etc.*

The special investigation, whose results will be given in the present paper, was undertaken in order to determine with as much accuracy as possible to what extent and where, the public health of Massachusetts is endangered by the pollution of air, water or soil from the escape into them of whatever comes under the head of sewage, including under this term, excrement, both solid and liquid, as well as the wet waste of dwellings and manufactories.

It will be taken for granted that the public knows that such sewage is poison, and not to be retained in the neighborhood of

* See the Act, page 8.

dwellings or workshops without great danger of breeding what are well termed filth-diseases, if taken into the human body through the lungs or the stomach, in the air we breathe or in the water we drink.

In order to obtain the necessary information, the State Board of Health issued the following circular, which was sent to each medical correspondent of the Board :—

COMMONWEALTH OF MASSACHUSETTS.

STATE BOARD OF HEALTH.

To the Medical Correspondent of the Board in ———.

DEAR SIR :—By a recent Act of the legislature, the State Board of Health is required to investigate the question of the use of running streams as sewers, etc., etc. The Board desire to make as complete a report as possible, and one which will be valuable for future reference, embracing articles by Dr. F. Winsor, on the “Sanitary Aspect of the Question”; by James P. Kirkwood, C. E., on “Sanitary Engineering as applied to our State”; and by the Secretary, on “Methods, etc., in use in Europe.”

Considering the importance of the subject, it is hoped that correspondents will be kind enough to send full and early answers to our circulars.

- I. Has your town (or city) introduced water; and, if so, from what source and with what effect, if any, on the health of the community?
- II. (a) Have you any system of sewers?
(b) If so, is it satisfactory?
(c) Where is the sewage discharged, and with what result to the health of the community?
- III. If no system of sewers, how is the sewage of families and of manufactories disposed of?
(a) About what proportion runs on to the surface?
(b) About what proportion runs into sink holes?
(c) About what proportion runs into cesspools?
(d) About what proportion runs under privies?
(e) About what proportion runs into ponds, brooks or rivers?
- IV. Is such sewage often or strongly offensive?
- V. Are wells or other sources of water-supply exposed to contamination from it?
- VI. Have you any experience of disease or serious discomfort resulting from sewage?

- VII. If any water-courses or ponds are used to receive sewage from manufactories or other sources in your town (or city), will you please give some account of them?
- (a) As to pollution of drinking water.
 - (b) As to pollution of the atmosphere, either by emanations from the contaminated water, or from flats, docks, banks of streams, etc.
 - (c) As to the effect of converting small streams into covered sewers.
 - (d) Any other facts that may occur to you.
- VIII. Have you in your town (or city), damp or wet cellars?
- (a) If so, have you noticed any apparent effect on the occupants of the houses?
- IX. Do you know of any case where the sewage of one town pollutes the air or the water of another? If so, please state circumstances.
- X. Please suggest such improvements in the matter of sewerage as you consider important in your town, either as to manufactories or otherwise.
- XI. Can you send water for analysis, if desired?

Dr. F. Winsor, of Winchester, has been commissioned by the Board to conduct this part of the investigation; and all replies should be addressed to him by the first of August, or sooner, if possible.

In behalf of the State Board of Health,

Very respectfully yours,

CHAS. F. FOLSOM, *Secretary*.

STATE HOUSE, June 1, 1875.

Answers were received from 188 cities and towns.

The same circular was sent to the city engineers of our largest ten cities, with the request that they would furnish answers to questions I, II, III, IV, V, VII, IX and X. Their answers supply much valuable information in addition to that received from the medical correspondents. There are in the Commonwealth 322 towns and 19 cities, comprising a population of 1,651,652. All the cities, and 169 towns, furnished replies. Their population amounts to 1,386,156, which is eighty-four per cent. of the whole.* A list of these towns, with their respective populations, follows:—

* The towns from which no replies have been received are most of them quite small. Only nine have a population exceeding 4,000.

Abington, . . .	3,241	Enfield, . . .	1,065
Amesbury, . . .	5,987	Everett, . . .	3,651
Amherst, . . .	3,937	Fairhaven, . . .	2,768
Andover, . . .	5,097	Fall River, . . .	45,340
Arlington, . . .	3,906	Falmouth, . . .	2,211
Ashburnham, . . .	2,141	Fitchburg, . . .	12,289
Ashby, . . .	962	Florida, . . .	572
Ashford, . . .	1,190	Foxborough, . . .	3,168
Athol, . . .	4,134	Gardner, . . .	3,730
Attleborough, . . .	9,224	Gloucester, . . .	16,754
Barnstable, . . .	4,302	Goshen, . . .	349
Barre, . . .	2,460	Gosnold, . . .	115
Belchertown, . . .	2,315	Grafton, . . .	4,442
Belmont, . . .	1,937	Granby, . . .	812
Berkley, . . .	781	Great Barrington, . . .	4,385
Berlin, . . .	987	Greenwich, . . .	606
Beverly, . . .	7,263	Groveland, . . .	2,084
Blackstone, . . .	4,640	Hadley, . . .	2,125
Blandford, . . .	964	Hardwick, . . .	1,992
Boston, . . .	341,919	Harvard, . . .	1,304
Braintree, . . .	4,156	Harwich, . . .	3,355
Brewster, . . .	1,219	Hatfield, . . .	1,500
Bridgewater, . . .	3,969	Haverhill, . . .	14,628
Brimfield, . . .	1,201	Heath, . . .	545
Brockton, . . .	10,578	Hingham, . . .	4,654
Brookfield, . . .	2,660	Holden, . . .	2,180
Brookline, . . .	6,675	Holyoke, . . .	15,260
Cambridge, . . .	47,838	Hopkinton, . . .	4,503
Canton, . . .	4,192	Hudson, . . .	3,493
Chatham, . . .	2,274	Huntington, . . .	1,095
Chelsea, . . .	20,695	Hyde Park, . . .	6,316
Chester, . . .	1,396	Ipswich, . . .	3,674
Chicopee, . . .	10,331	Kingston, . . .	1,569
Clinton, . . .	6,781	Lancaster, . . .	1,957
Colrain, . . .	1,699	Lawrence, . . .	34,907
Concord, . . .	2,676	Leicester, . . .	2,770
Danvers, . . .	6,024	Leominster, . . .	5,201
Dennis, . . .	3,369	Leverett, . . .	831
Dover, . . .	650	Lexington, . . .	2,555
Dudley, . . .	2,653	Littleton, . . .	950
East Bridgewater, . . .	2,808	Lowell, . . .	49,677
Eastham, . . .	639	Ludlow, . . .	1,222
Easthampton, . . .	3,964	Lunenburg, . . .	1,153
Easton, . . .	3,898	Lynn, . . .	32,600

Malden, . . .	10,843	Reading, . . .	3,186
Mansfield, . . .	2,656	Revere, . . .	1,603
Marblehead, . . .	7,677	Richmond, . . .	1,141
Mattapoisett, . . .	1,361	Rockport, . . .	4,490
Medford, . . .	6,627	Rowe, . . .	661
Medway, . . .	4,242	Rutland, . . .	1,030
Middleborough, . . .	5,023	Salem, . . .	25,955
Middlefield, . . .	603	Sandwich, . . .	3,417
Milford, . . .	9,818	Sheffield, . . .	2,233
Millbury, . . .	4,529	Shelburne, . . .	1,590
Monson, . . .	3,733	Sherborn, . . .	999
Montague, . . .	3,380	Shirley, . . .	1,352
Monterey, . . .	703	Shrewsbury, . . .	1,524
Montgomery, . . .	304	Shutesbury, . . .	558
Mount Washington, . . .	177	Somerset, . . .	1,940
Nahant, . . .	766	Somerville, . . .	21,868
Nantucket, . . .	3,201	South Hadley, . . .	3,370
Natick, . . .	7,419	South Scituate, . . .	1,818
Needham, . . .	4,548	Springfield, . . .	31,053
New Bedford, . . .	25,876	Stockbridge, . . .	2,089
New Braintree, . . .	603	Stoneham, . . .	4,984
Newburyport, . . .	13,323	Stoughton, . . .	4,842
New Salem, . . .	923	Sudbury, . . .	1,177
Newton, . . .	16,105	Sutton, . . .	3,051
North Adams, . . .	15,760	Swampscott, . . .	2,128
Northampton, . . .	11,108	Taunton, . . .	20,429
North Andover, . . .	2,981	Tewksbury, . . .	1,997
Northborough, . . .	1,398	Tisbury, . . .	1,525
Northbridge, . . .	4,030	Topsfield, . . .	1,221
North Reading, . . .	979	Tyringham, . . .	517
Orange, . . .	2,497	Upton, . . .	2,125
Orleans, . . .	1,373	Uxbridge, . . .	3,029
Otis, . . .	855	Wakefield, . . .	5,349
Oxford, . . .	2,938	Walpole, . . .	2,290
Palmer, . . .	4,572	Waltham, . . .	9,945
Peabody, . . .	866	Ware, . . .	4,142
Pembroke, . . .	1,399	Warren, . . .	3,260
Pepperell, . . .	1,924	Watertown, . . .	5,099
Pittsfield, . . .	12,267	Webster, . . .	5,059
Plainfield, . . .	481	Westborough, . . .	5,140
Plymouth, . . .	6,370	West Brookfield, . . .	1,903
Quincy, . . .	9,155	Westfield, . . .	8,429
Randolph, . . .	4,061	Westhampton, . . .	556
Raynham, . . .	1,687	West Newbury, . . .	2,021

West Springfield, . . .	3,739	Winchester, . . .	3,099
West Stockbridge, . . .	1,981	Winthrop, . . .	663
Weymouth, . . .	9,819	Woburn, . . .	9,568
Wilbraham, . . .	2,576	Worcester, . . .	49,265
Williamsburg, . . .	2,029	Worthington, . . .	818
Wilmington, . . .	879	Wrentham, . . .	2,395

One hundred and fifty-three towns have failed to respond to the circulars.

Fifty-one of these have less than 1,000 inhabitants; 63 have between 1,000 and 2,000 inhabitants; 21 have between 2,000 and 3,000 inhabitants; 9 have between 3,000 and 4,000 inhabitants; 4 have between 4,000 and 5,000 inhabitants; 4 have between 5,000 and 6,000 inhabitants; 1 has between 8,000 and 9,000 inhabitants.

EXCREMENT REMOVAL.

Of all forms of filth the most dangerous, as well as the most offensive and most common, is fecal excrement. Cast off by the human economy as not only incapable of furnishing any support, but utterly unfit to be longer retained in contact with the living body, it is nevertheless stored in the near neighborhood of most dwellings and of very many wells throughout the Commonwealth. It lies beneath privies, or in the cesspools which receive the wash from water-closets, dissolving and oozing more or less rapidly into the surrounding soil, from which it sometimes finds its way into some neighboring well, sometimes rises in gaseous form to poison the air, sometimes lies stored and lurking to infect any dwelling whose cellar may be dug into its ambush-ground with "mysterious" unwholesomeness. If any portion of that which finds its way into drinking water came from a person suffering with typhoid fever, cholera, dysentery, or with certain forms of intestinal worms, it sows the specific seeds of those diseases in many new victims till they multiply themselves manifold. Investigations carried to the point of demonstration in England have shown that several severe and extensive epidemics of typhoid fever have originated in milk brought from many miles away in the country and infected with water, into which a most minute amount of typhoid *excreta* had been washed

from an adjacent and neglected privy. There is no means known of purifying excrement on a large scale except by the roots of growing vegetation, and it does not become us to be positive that even this method can be depended on to disinfect that which carries the specific poison of cholera or of certain parasites.

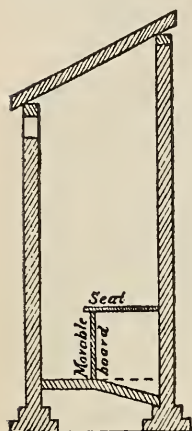
The only proper way to deal with excrement is *to carry it as fast and as far away from human dwellings as possible*; and without doubt the best way to effect this is by a complete system of water-carriage. But such a system must be thorough, or it will expose us to dangers in our very sleeping-rooms. The subtle and, to most persons, the unsuspected ways in which these dangers arise, as well as the means by which they may be avoided, will be fully discussed in another part of the present volume, and therefore do not require notice here.

But the great majority of dwellings cannot be furnished with water-closets, and must depend upon some form of privy. It therefore becomes a question of the greatest sanitary importance what form is to be preferred. The things to be sought are :

- (a.) Ease and inoffensiveness in removing the excrement.
- (b.) Security against its being absorbed by the material of the receptacle in which it is temporarily retained or by the adjacent soil.
- (c.) Security against offence.
- (d.) Economy.

In the second report of the medical officer of the Privy Council, England, 1874, is a paper by J. Netton Radcliffe on various ways of excrement-removal in use in Great Britain, which supplies a deal of valuable practical information, and from which several of the accompanying illustrations are borrowed. In all of them it will be observed that the receptacles are small, made of impervious material, easily emptied or removed, and cheap. It is the practice to add to their contents the family coal-ashes, either at every time of using or at short intervals. The largest is emptied as often as once a week, the smallest once a day. No "slops" from chamber or kitchen are allowed to be thrown in. By the adoption of some one of these methods several large towns and cities in

England and Scotland have rid themselves of most dangerous and disgusting nuisances in their most densely settled parts, substituting for them an arrangement at once more decent, cleanly, convenient and economical.

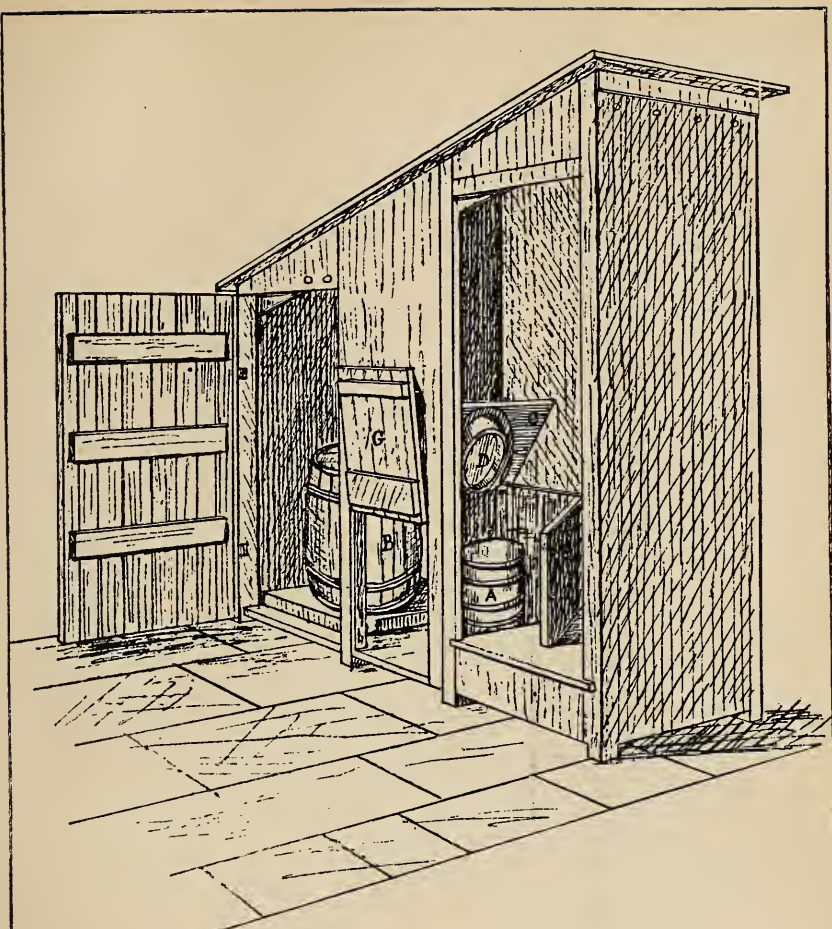


Hull Pattern (section).
Scale, 4 feet to an inch.

The privy used in Hull, here shown, is the simplest of all, and occupies the least space. The floor of the receptacle is of impervious material. Ashes and the dry refuse of the house are thrown down the seat, making with the excrement a dry, inoffensive mass, which is removed once a week with a spade, by removing the "movable board."

The Rochdale "pail-closet" system has been in use since 1868, and was thoroughly inspected and approved by Mr. Radcliffe in 1869. In 1874 he again inspected it, and gave it his unqualified approval. It consists of a closet (out of doors) of strong and simple construction, beneath the seat of which is placed a "pail" made from half a kerosene barrel, capable of holding one hundred pounds; but in fact the average weight of its contents after a week's use by an ordinary family proved to be forty-one pounds. This is removed weekly, and an empty and disinfected "pail" is substituted. In the case of very large families, or of workshops, the removal is made twice or thrice a week. At the time of removal, a tightly fitting metal lid is placed upon the pail. "The process of removal is quite inoffensive," and is *systematically performed*. The population of Rochdale in 1871 was 67,754; inhabited houses, 13,938; of which 2,944 were fitted with "pail-closets," used by 11,770 persons. In 1874 the number of houses so fitted was 7,287, used by 43,500 persons, when Mr. Radcliffe reported essentially as follows:—

That the system of removal had been thoroughly approved by all who had had experience of it; and that it had not failed under the most varied circumstances, having proved equally efficacious in the highly rented house with its own closet, in the lodging house where great numbers were accommodated, and in the factory and workshop.



*Rochdale Corporation
Pattern Pail closet.*

- A. excrement pail.*
- B. ash tub.*
- C. seat cover (raised)*
- D. iron collar below seat, reaching slightly into pail when cover is down.*
- F. hinged upright of seat*
- G. door admitting from outside to excrement pail.*

MANCHESTER CORPORATION.
DRY ASH CLOSET. - SECTION.



The system includes removal of "dry dirt," too. This is sifted, and the fine ash is used in the process of manure manufacture; trenches are made in it, and the contents of the excrement-pails dumped there; more fine ash is placed above, and a quantity of sulphuric acid added to hasten drying. In five weeks the mass is pulverulent and inodorous.

In the finished manure there are eighty parts of excrement to thirty-five parts of fine coal-ash; twenty-five pounds of sulphuric acid are added to each ton.

Under the old midden (privy) system, in Rochdale, the cost of the removal of the excrement of one thousand persons for one year was £71. Under the "pail-closet" system, it was £19; the resulting manure selling for three-fourths of the cost of collecting and preparing it. The cost of a "pail" complete, was 4s. 9d.

As to the working of the pail-system. The movableness of the pails is their great recommendation—the facility which the system gives for frequent, thorough removal, being enormous.

In this connection, it is impossible not to be struck with the advantage that a pail-system has in relation to diseased excrement. The facility and thoroughness with which any required chemical disinfection can be done, and the way in which the excrement itself can be wholly got rid of, leaving none of its products behind—nothing soaking into the ground, or hanging about midden-pits or sewers, obviously suggest most important powers possessed by this system for preventing the spread of excremental diseases.

In Manchester the use of dry coal-ash as a deodorizer is combined with a "pail-closet" system much like that of Rochdale. The receptacle for excrement is of galvanized iron, fifteen inches high, eighteen inches in diameter, and of a capacity of ten gallons. These are removed weekly for most families, twice or thrice a week for very large ones, fortnightly for very small and neat ones. This system had not been in operation two years when inspected by Mr. Radcliffe, but it received his approval, though not quite so unreservedly as that of Rochdale. The addition of dry coal-ash is an improvement, but the metal pail is inferior to the strong wooden one made from the kerosene barrel; and the sinking of the pit, in which the Manchester pail stands, below the surface of the ground, is

objectionable, as it makes removal more difficult. At the time of inspection the system had been applied to 6,000 of the 67,000 houses in Manchester, and was being extended at the rate of 5,000 houses annually. As at Rochdale, the removed excrement was composted into a marketable manure.

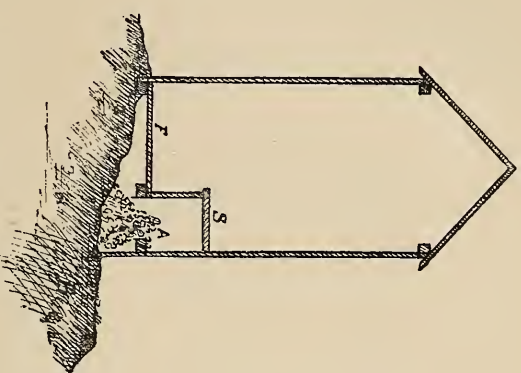
In all the pail-systems, some form of urine-conductor is used.

There would seem to be every reason why the law should require all factories, tenements and boarding-houses, not furnished with a satisfactory system of water-closets, to adopt some modification of this plan. At present many factories, whose operatives are numbered by scores and hundreds, have privies overhanging the streams which furnish power. This is *water-carriage* indeed! carrying, in many cases, the most dangerous and disgusting form of pollution to spoil the stream below.

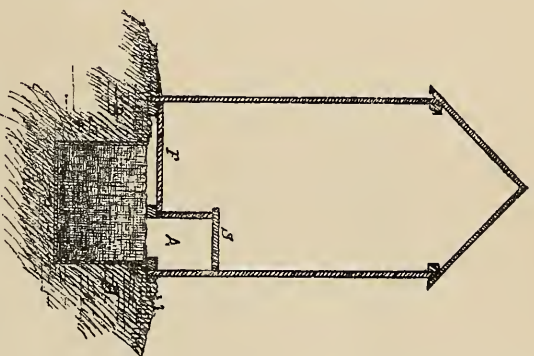
The figure on page 185 shows a slight variation on one of the foregoing, which is occasionally seen in use in the United States, and seems on the whole preferable to any which the writer has seen. There is no reason why any family, unprovided with a water-closet, should not at once substitute one of the preceding apparatuses for its present privy. Such a change involves but little expense or trouble, and it would put the matter of the disposal of fecal excrement on a footing altogether satisfactory, whether from a sanitary or a social point of view.

Every one admits that the methods now in almost universal use are anything but satisfactory; that most of them are offensive, often disgusting. The diagrams here shown illustrate some forms very common in country towns, and the manner in which they lead to the pollution of the surrounding ground and of any well near them.

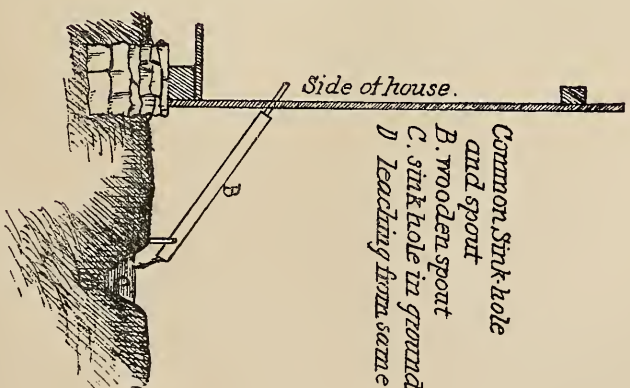
It may be said that the simplest and cheapest of those shown on the opposite page, one much in use in the small country towns, involves the minimum of annoyance and risk, since whatever fecal accumulation occurs is all on the surface, and is in such free communication with the outer air as to be rapidly dried and disinfected. But at the best it pollutes the soil beneath more than is suspected. It is not cleared out one-tenth as often as is needed, and it exposes those who use



*Section of common style of
country privy on a slope
F. floor.
S. seat.
A. excrement.
B. leaching of fluids into soil.*

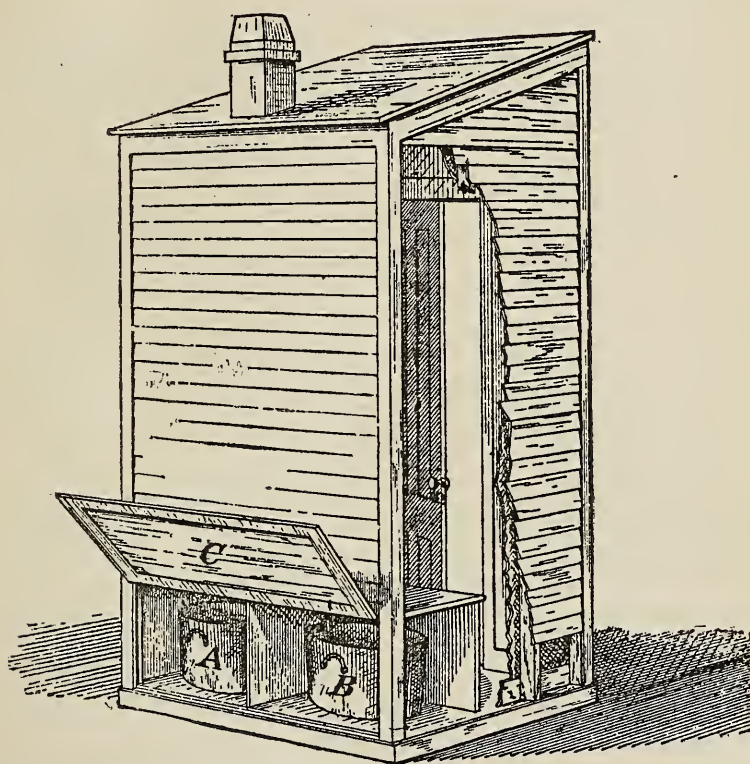


*Section of Privy with pit,
and board sides*



*Common Sink-hole
and spout
B. wooden spout
C. sink hole in ground
D. leaching from sewer.*

it to the inclemencies of the weather to a dangerous extent; while for every form of privy which has any pit-receptacle—from a hole in the ground to a vault bricked and cemented—the sanitarian can have nothing but reprobation. Those that leak, as most do, pollute the ground; those that are tight,



PRIVY USED IN THE UNITED STATES.

A. Excrement tub. B. Tub of dry earth. C. Hinged portion of back of privy.

poison the air. The more they hold, the worse they are, because the older such undiluted wet filth is, the more dangerously poisonous is it.

It is amazing how blindly and recklessly this privy-poisoning of the ground is persisted in in many places. The strongest instance within the writer's knowledge is found in Three Rivers, Canada East, a town of about 6,000 inhabitants. There, with every natural facility for drainage and sewerage,

it has for two hundred years been the practice to move the privy from one part of the house-lot to another, as the ground beneath its last resting-place became unendurably offensive. Of course typhoid fever is endemic, *domiciled* in that town; and medical skill struggles vainly with nastiness, as it must in every growing town which will not abandon the present privy system.

It will be remarked that the methods here recommended are, as it were, primitive forms of the earth-closet. But they have the advantage over it, not only in original cheapness, but in simplicity, and in not claiming to be suited for use within the house walls. It is the general verdict of those who have watched the earth-closet, with the hope that it would make good its claims, that it is never a success unless where managed with exceptional intelligence and vigilance; a qualification which makes it unavailable for the community at large. How satisfactory it may prove, under proper conditions, is admirably shown in the following extracts from letters from Dr. R. S. Steuart, Medical Superintendent of the Maryland Hospital for the Insane:—

“In 1852, our site was purchased, thirty-six acres. It is five hundred feet above the harbor of the city of Baltimore; and the land falls gradually to the water, six miles distant. Our building fronts to the east; the wings extend north and south 225 feet each. The drainage on either side follows a natural ravine. Beyond the ravine on the north side is a fine stream made by the convergence of thirteen good springs; this stream flows over a granite bed, and affords an abundant supply of good water, forced to the top of our centre and wings into large tanks, holding fifty thousand gallons of water. This supply was freely used for bathing and for water-closets, all constructed in the best manner and acting perfectly. I must now state that the extensive area of land between our institution and tide-water was almost uninhabited when our site was purchased in 1852.

“Many causes delayed the completion of our hospital till 1872, and, during the twenty years’ interval, many fine villas were erected with the modern improvements for raising water for domestic purposes; and from the owners of these we received in 1873 notice of the fact that several of the streamlets supplying them had become polluted by the drainage from our cesspools. Many expedients were tried to remedy this, but all failed; we acknowledged the fact,

and agreed to pay damages according to circumstances, amounting to \$3,000.

“We then, to avoid all future complaints, determined to adopt the earth or rather ash closets. These have been in operation eight months, and so far we hear no more complaints from our neighbors, far or near. We have organized a system by which the hods or buckets are removed twice or thrice a day, and carried to a convenient depot, where a compost is formed on our own grounds, producing very little bad odor on the spot, and none at all at a distance of fifty feet; and we have the satisfaction to witness the good fertilizing effects of this compost on our fields and gardens.

“You also ask about the drainage of the water from the bathtubs and from the kitchens. We have found that the water now discharged beyond our pipes does not indicate any signs of pollution, and is regarded to be as pure and available as the water from other streams in this section of the county.”

In reply to further questions, Dr. Steuart wrote as follows:—

“DECEMBER 4, 1875.

“My first plan was to have a large cesspool or well on each side of the hospital, twenty feet in diameter and twenty-five feet deep. Into these the drain-pipes, ten inches in diameter, flowed, taking all the flow from the house. I had presumed that the sinking of the contents into the earth would preclude all overflow. In this I was disappointed; the nature of the stratification below, in a few months, caused the accumulation to run out over our own grounds, and pass onwards. I then made other wells, three hundred yards off, to receive this flow, and, beyond these, filters were made of sand, gravel and charcoal. These second wells also overflowed; and although the fluid that passed off through the filter was clear and apparently innocent of all offensive matter, yet the smell was so offensive to our near neighbors as to make it necessary to abate this nuisance. These several experiments cost a great deal. To end the matter, the ash-closets were adopted.

The buckets are removed, morning and evening, and in some places three times a day. They are carried by private staircases, down to the basement, thence along these lower regions to an exit at the north wing, where they are emptied into a cart, constructed as the old-fashioned night-carts are; quite close, no leaking. The carts dump their contents at a convenient depot; stable-manure and some gypsum are added, so as to deaden the smell, and to improve the manure. It was the *overflow* our neighbors complained of.

“ We have 220 patients and attendants, but only two of the latter, and a half-dozen of the paupers, are engaged in the removal of the buckets. Sometimes the agents in this dirty work complain of nausea; still I have no difficulty in getting men to do it. The only difficulty I have so far found is in the addition of too much liquid matter to the solids in the buckets. It should not be softer than mortar about to be used in brick buildings. If too liquid, the smell is intense. We have separate urine buckets.”

Of course a system of removal must form a part of every plan of small unabsorbent receptacles; but this is so purely an executive matter as to need no discussion here. It is enough to say that such removal involves no annoyance to household or neighborhood; that it should be to some spot as distant as possible from inhabited buildings; that additional absorbents should be used at the place of deposit; and, finally, that the resulting compound should be applied at the earliest possible moment to growing crops, the only effectual means of disinfecting, on a large scale, such matters. The system is equally applicable to the small, isolated country house and to the crowded tenement house in the great city.

Where the present system of receptacle-vaults is persisted in, the local authorities should strictly prohibit the practice of emptying by the vile bucket and night-soil cart so long in use, and require that the work be done by some of the “odorless” machines now operating successfully in many cities, requiring also that the emptying should be done at much shorter intervals, to which the community will readily agree when they are satisfied that it can be done in one-tenth of the time and with one-hundredth part of the stench and outrage to decency which characterizes the method now in vogue, and which prevents any one from adopting it so long as it can possibly be deferred. Add to these advantages that of doing the emptying by the “odorless” process by day, and it only remains to show that it involves no more expense in order to insure its adoption wherever vaults and cesspools must be used.

There are several varieties of these “odorless” apparatuses, one of which can be obtained on the following terms: For a town of a population not exceeding 10,000, the right of use during ten years can be had for \$300, and a complete set

of apparatus for \$350 more. Thus equipped, any town, either by its own teams and workmen, or by contract, might thoroughly, inoffensively and quickly empty, by daylight, not only privy-vaults and cesspools, but "pond-holes," stagnant pools, etc. Odorless transportation, in manageable packages, forms part of the system, so that the matters removed can be offered, "in lots to suit purchasers," in the form of valuable fluid fertilizers. Surely a town making this investment could depend upon receiving in cash a sum sufficient to keep the apparatus in order and pay interest on the \$650 expended.

There are various plans for the disposal of kitchen-sewage by overflow drains, in order to irrigate gardens and lawns, the receptacle tanks being emptied (or drawn down) automatically. These are excellent for climates milder than that of Massachusetts, but would require special protection from frost, which sometimes penetrates the ground to the depth of six feet and seriously interferes with such drainage for four months of the year. Yet we may hope to find some simple and effectual method of protection against cold, remembering that the temperature of sewage itself is ordinarily several degrees above freezing.

Next in importance to the question of excrement receptacles and removal is the question of cesspools and their emptying. To begin with, let us understand that the only proper way to make a cesspool is to make it as tight as possible, so that it cannot seriously pollute the soil without overflowing. A regard for health forbids our letting "sink-slops" and "chamber-slops" soak into the ground about a dwelling. They are sometimes poisonous, even at the moment they are discharged from the house, and are always quick to undergo decomposition and give off gases which are slow poison. Quick as these fluids are to undergo decomposition, they are slow to cease this process. They retain for weeks enough material to continue to generate their gaseous poison or to bear it in solution to wells and cisterns distant many feet and sometimes many rods; and then there is disease, if not death, in the cup we drink and the air we breathe. And all the while the earth about the cesspool is becoming more and more filled with filth, till it is saturated and incapable of straining out any more from the water that oozes into it.

Then, if it be a porous soil, the ooze from the cesspool must carry its filth farther and farther from the centre of pollution. If it be a retentive soil, it becomes "puddled," so as to make the cesspool tight, in which case it soon overflows and forces the owner to make some attempt at sanitary reform. Not so in the case of the cesspool which continues to let its contents leach away. Every heavy rain, every spring thaw, washes a portion of the filth out of its bed in the soil into the nearest well. For every well is the *drain* for the moisture of a circumjacent region, which, at its minimum, corresponds to an inverted cone, with its apex at the bottom of the well, and with a base on the surface of the ground at least as broad as the well is deep. This is shown by the diagram.

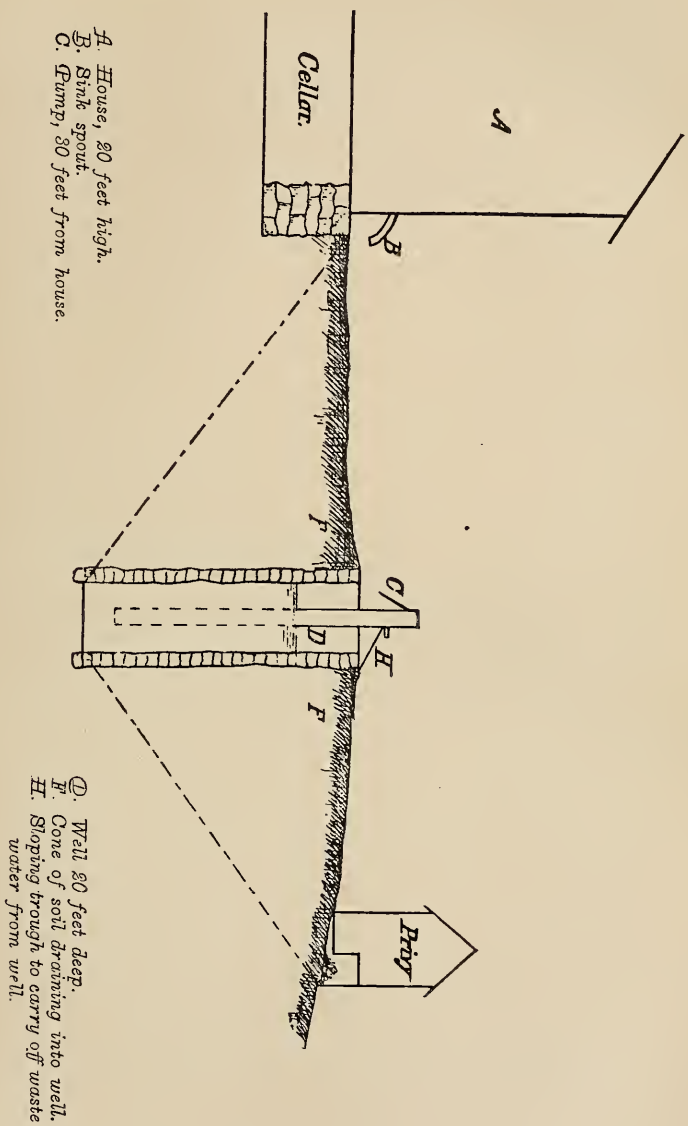
But most wells drain a much larger region, and if sunk in an impervious, inclined stratum or on a slope, they may drain localities many rods distant. One has only to consider the case of a densely peopled hillside to realize the inevitable pollution of wells from leaking cesspools or drains farther up the slope.

The report of Mr. Child, officer of health for certain districts in Oxfordshire, England, contains a striking instance of fouling of wells from a source above their level, which has been quoted by the "Medical Commission upon the Sanitary Qualities of the Sudbury, Mystic, Shawshine and Charles River Waters," in their report.* It is reproduced here as forcibly illustrating the danger in question:—

"In consequence of the escape of the contents of a barrel of petroleum or benzoline, which had been buried in an orchard, a circuit of wells sixty feet below and 250 or 300 yards distant became so affected that the occupiers of fifteen houses, containing eighty-two inhabitants, were for ten days unable to use the water for drinking or cooking. The cattle of one of the proprietors, moreover, refused to drink at the spring where they were accustomed to drink. Had this soakage been sewage instead of petroleum, who can doubt that the result might have been wholesale water-poisoning and an outbreak of typhoid fever?"

Now, it is a very moderate statement to say that nine out of ten cesspools, the State over, do leak, and are constructed

* City Document, No. 102. Boston, 1874.





expressly to leak, and thus save the expense, labor and nuisance of frequent emptying. And it is obvious that as soon as any town obtains an abundant water-supply by aqueduct, its sewage is immensely increased (from six to ten or more times), so as to make the old method of drainage altogether inadequate to the new order of things. Yet, how many of the towns which have recently introduced water or have begun water-works, are providing any adequate system of drainage? The "water committees," or "commissioners," do not dare to tell the truth to the town, because of the great additional expense involved. They know that the necessity will become apparent in a few years after their water-supply goes into operation, and must then be met at an outlay much greater than would suffice if sewerage-works went side by side with laying of water-pipes.

In addition to the expense, there must arise the usually embarrassing question, Where shall be the outlet of the sewerage system, if it is undertaken? In the answering of this question, neighboring towns, as well as individuals, must be consulted, and vexatious and costly litigation may follow. This problem of the disposal of sewage, in which health and comfort are balanced against cost, is before many of our towns and cities to-day, and in the solution of it the smaller towns may be greatly helped by these odorless emptying machines. As was said under the head of excrement-removal, let it be obligatory on every householder to make his cesspool as tight* as possible, and to empty it by the new method alone, and the sanitary requirements may be met without incurring a great town debt and without wasting the sewage. Meanwhile, and also by the adoption, on suitable lots of land, of the plan of private irrigation by drain-tile, elsewhere suggested, valuable experience may be acquired to assist in solving the important question of irrigation on a large scale.

WATER-SUPPLY.

There are three forms of water-supply: wells, cisterns, aqueducts. Of these, the first has, of course, been that in

* The action of frost, the jarring of the earth from various causes, and imperfections in workmanship render it impossible, practically speaking, to keep cesspools *perfectly* tight.

general use in Massachusetts, as it must long continue to be in most towns not closely built up. To what forms of pollution it is exposed from privies, "sinks," cesspools, stables, etc., has been shown under a previous head. Whenever dwellings are within one hundred feet of each other, even on a level surface, there is danger that one may pollute the other's well through some one of the above-named agencies. It may quicken the reader's sense of this danger to construct a diagram of four houses, each within one hundred feet of the other three, to locate the privy, cesspool, stable, hen-house and well of each as these are ordinarily placed, and then, making another diagram, showing a vertical section of one of these wells, thirty feet deep, to study its possible action as a drain of the neighboring surface, especially in the case of dwellings so circumstanced for many years. Such a neighborhood, however, would never be considered a close one. How is it with the wells of houses whose walls touch each other? How with those of houses situated below numbers of others on a slope?

However free a well may be from danger of drainage-pollution, it should be examined yearly in the dry season, and cleared of all droppings and settlements. Wood from curbing or pump, dirt from the sides, burrowing animals, earthworms, slugs, etc., etc., are often found rotting in the bottoms of wells. Of course the cleaning is not thorough unless a man descends, examines and remedies all defects.

Cisterns are liable to the same dangers with wells, and usually have carried into them much more fine dirt in suspension, washed away from the roofs which form their "water-shed." Even when made with an effective filter-chamber, they should be examined and cleaned every summer—oftener, if their water grows distasteful. Who is not familiar with the strong smell of water from cisterns, which has been furnished him for bathing? Cisterns are also liable to be cracked or burst by pressure from within or without, in consequence of the soil around them not affording support enough; or by pressure from beneath, as the subsoil water rises. Being thus rendered leaky under pressure from without, they are occasionally entered by polluted water at times when their contents cannot leak against the external pressure. From

just such a cause there occurred in the autumn of 1874 an epidemic of typhoid fever in a boarding school in Burlington, New Jersey, a full report of which may be found in the "Philadelphia Medical Times" for May 29, 1875. It is interesting to note that the infecting agent in this case was the leakage into the subsoil from a privy-vault which had been strongly and carefully built only three years before.

The "overflow" of cisterns furnishes another channel of possible contagion, which should be borne in mind, as capable of admitting gases as well as fluids. It being probable that cisterns will be more and more used as substitutes for wells, where soil-contamination is on the increase, and before an aqueduct supply is secured, it is important that they should be built and maintained with intelligent care, and that their owners should not rest secure in the idea that because they no longer use well-water they are in no danger of drinking fouled water. Whatever be the source of supply, "eternal vigilance is the price," the only price, of safety.

The aqueduct, the third source of supply, is the method which all large towns must of necessity resort to, and which, apart from the question of cost, commends itself to all communities by its convenience, its abundance, and its comparative purity. In our Commonwealth it has already been adopted with more or less completeness by forty-six cities and towns, comprising 963,721 persons, or a little over one-half of the entire population.

WATER-SUPPLY AND SEWERAGE.

In the following five tables are gathered certain statistics in regard to the towns thus supplied. It is probable that it is not complete as regards all the smaller towns of the State, which, having partial aqueduct supplies, have not replied to the circular of the Board. Another year will undoubtedly remedy this incompleteness, and meanwhile it is certain that we have some facts in regard to all the larger towns. It would be interesting to know how many towns are now discussing the question of a public water-supply, since it is evident that there is a general awakening to the importance as well as the convenience of it.

These tables furnish, with as much completeness as has

Twelve Cities supplied by Aqueduct, having a population of 20,000 and more.

CITY OR TOWN.	Effect on health.	Dwellings.	Dwellings taking water.	Population.	WATER.		SEWERS.	
					Source of Supply and Date of Introduction.	Daily capacity in gallons.	Total length, in miles.	Where discharged.
Boston, ¹ . .	Some improvement,	-	-	341,919	Lake Cochituate, 1848; Jamaica Pond, 1840; Mystic Lake, 1870; Sudbury River, 1873.	64,000,000	166	The outlets encircle the city proper.
Cambridge, ² .	Probable benefit, but no proof.	7,769	-	47,838	Fresh Pond, 1857; Spy and Little ponds, 1875.	8,000,000	40	Charles River, Alewife Brk.
(Charlestown, ³)	Not proved to be affected.	-	-	†	Mystic Pond, . . .	-	-	Charles, Mystic and Miller's rivers.
Chelsea, ⁴ . .	Thought to be favorable.	3,831	-	20,695	Mystic Pond, . . .	Mystic supply, 12,000,000	17	Chelsea Creek, Mystic River.
Fall River, ⁵ .	Improved, where used.	4,610	-	43,340	Wauuppa Lake, . . .	-	-	Mt. Hope Bay, partly by way of "Fall River."
Lawrence, ⁶ .	Too recent, . . .	4,279	-	34,907	Merrimac River, . . .	-	-	Merrimac, Spicket and Shawshine Rivers.
Lowell, . .	Good; typhoid believed to be lessened.	7,800	-	49,677	Merrimac River, through filter-chamber, 1872-3.	2,500,000	13.4	Concord River, Merrimac River.
Lynn, ⁷ . .	Statistics show decrease of typhoid.	5,667	3,585	32,600	Two ponds, made by damming brooks on the edge of city, 1870.	1,500,000	7	Lynn Harbor.
New Bedford, ⁸ .	Less typhoid, . .	3,998	15,000 persons supplied.	23,876	Acushnet River, dammed,	Enough for four-fifths of population.	14	New Bedford Harbor, twelve outfalls into deep water.

Salom, ⁹	Partial supply for years. No change since full supply.	2,883	-	25,956	Wenham Lake, . . .	-	-	Harbor, North River, Mill Pond.
Somerville, ¹⁰	Very good; less typhoid and kindred diseases.	3,908	-	21,868	Mystic Pond, . . .	-	14	Charles River, Mystic River.
Springfield, ¹¹	Too recent, . . .	4,977	-	31,053	Reservoir in Ludlow, .	-	-	Connecticut River.
Worcester, ¹²	Good; less typhoid,	6,095	-	49,265	Reservoir, fed by Lynde Brook,	-	-	Blackstone River, by Mill Brook.
				726,993				

Nine Cities and Towns supplied by Aqueduct. Population from 10,000 to 20,000.

Adams, ¹³	Can hardly be ascertained, but advantageous.	2,002	Eight hundred families.	15,760	Mountain stream, 1865, .	Varies from 2½ to 6 millions.	-	No sewers.
Brockton, ¹⁴	Unpalatable; not used for drinking or cooking.	1,769	One-fourth of all, perhaps less.	10,578	Pumped from large brook to small reservoir in centre, 1870.	Small, . . .	-	No sewers.
Chicopee, ¹⁵	Diarrhea when the season of low and impure supply occurs.	1,214	Nearly all, .	10,331	Private Co. Springs in high plateau, 1830.	Scanty and intermittent.	-	No sewers.

* Average daily use 1,329,290 gallons.

† Used lavishly.

‡ Included in Boston.

¹ Sewerage very unsatisfactory.

² Sewerage very unsatisfactory.

³ "Fall River" portion, sewerage unsatisfactory.

⁴ Sewerage bad.

⁵ Harbor portion, sewerage unsatisfactory; North River portion vile; easily remedied.

⁶ Sewerage very unsatisfactory.

⁷ Fouls the river visibly for seven miles; discussing a system of irrigation, and rapidly improving sewerage within city.

⁸ Has rapid surface-drainage into Hoosac River.

⁹ Sewerage very unsatisfactory.

¹⁰ Sewerage calls for improvement.

¹¹ Merrimac portion, sewerage satisfactory; Spicket portion unsatisfactory.

¹² Sewerage very satisfactory.

¹³ Good plan of sewerage begun upon.

¹⁴ Two-thirds sewerage runs on surface.

¹⁵ Drains finally into Connecticut River.

Nine Cities and Towns supplied by Aqueduct. Population 10,000 to 20,000—Concluded.

CITY OR TOWN.	Effect on health.	Dwellings.	Dwellings taking water.	Population.	WATER.		SEWERS.	
					Source of Supply and Date of Introduction.	Daily capacity, in gallons.	Total length, in miles.	Where discharged.
Fitchburg, ¹	Too recent; still, thought to be less sickness.	1,974	-	12,289	Reservoir fed by small stream, 1871-72.	One million, can be trebled.	-	Nashua River.
Haverhill, ²	Salutary, . . .	2,643	10,000 persons.	14,628	Three ponds, 1801; and Merrimac River, 1848. Private Co.	Capable of indefinite increase.	-	Merrimac River, Little River.
Holyoke, ³	None observable, .	1,479	-	16,260	Deep, natural ponds, 1872; abundant and pure.	3,000,000	-	Connecticut River.
Malden, . .	Decidedly good, .	1,923	-	10,843	Spot Pond, 1870, . .	-	-	Cesspools.
Northampton, ⁴	Too recent, . . .	1,823	-	11,108	Mountain stream, 1871, .	-	-	No system.
Pittsfield, . .	Generally thought to be improved.	2,052	-	12,267 114,064	Ashley Lake, 1855; Sacket Brook, 1875.	-	2	West Branch of Housatonic River.

Ten Towns supplied by Aqueduct. Population from 5,000 to 10,000.

CITY OR TOWN.	Effect on health.	Dwellings.	Dwellings taking water.	Population.	WATER.		SEWERS.	
					Source of Supply and Date of Introduction.	Daily capacity, in gallons.	Total length, in miles.	Where discharged.
Attleborough, ⁵	No appreciable effect as yet.	1,520	-	9,224	Ten Mile Brook and large well, 1874.	Maximum, 800,280	-	None.
Beverly, ⁶	Good; much less fever, especially typhoid.	1,399	-	7,263	Wenham Lake, . . .	-	-	None.
(Brighton, ⁷)	Too recent, . . .	997	-		Lake Cochituate, 1875-6, .	-	-	Natural outlet, Charles River.

Brookline, ¹	Too recent, . . .	1,095	370	6,675	Charles River, by filtering-chamber, 1875-6.	1,500,000	3	Charles River, through Mud-dy Brook, with tide-gate.
Medford, ²	Considered good, . .	1,374	1,100 takers.	6,627	Spot Pond, 1870, . .	-	-	No system. Drains into Mystic River.
Natick, ¹⁰	No perceptible effect as yet.	1,195	-	4,419	Dug Pond, ...	-	-	No system.
Peabody, ¹¹	Partial supply; no typhoid among water takers.	1,350	-	8,066	-	-	-	Tanneries, etc., and some dwellings, into Procter's Brook and Goldthwaite's Brook, thence into North River in Salem.
Plymouth, ¹²	Typhoid the rarest disease.	1,238	-	6,370	Large natural pond, 1856,	-	-	Plymouth Harbor, bare at low tide.
Waltham, ¹³	Too recent, . . .	1,317	-	9,945	Charles River by filtering-chamber, 1874.	1,250,000	-	No system. Natural outlet into Charles River.
Westfield, ¹⁴	Too recent, . . .	1,463	-	8,429	Two reservoirs, by damming brook five miles distant.	-	-	No sewers.
Woburn, ¹⁵	More sickness in two years since water than in preceding two.	1,626	-	9,568 76,536	Wells at Horn Pond, 1873,	1,200,000	-	Natural outlet into head waters of Mystic Pond, where most of the tanneries now discharge, also some dwellings.

* Average daily use, 75,000 gallons.

§ Average daily use, 170,000 gallons.

† Average daily use, in summer, 320,000 gallons.

‡ Average daily use, 600,000 gallons.
|| Included in Boston.

1 Beginning to execute a plan for sewerage. River already fouled to sight, but not to smell. 2 Little River Valley in a bad condition. See Haverhill in Report.

3 Has a plan of sewerage, and is executing it. 4 Into brooks and Mill Brook. 5 Much needed. Sewerage under discussion.

6 Much needed. 7 Sewerage system begun upon, together with introduction of water. 8 A good system begun upon systematically. Outlet objectionable to Boston. 9 Cesspools generally in use.

10 Most of the sewage runs into Pegan Brook, thence into Lake Cochituate. 11 See Report on Peabody and Salem. Open stream through centre, the main sewer.

12 Existing sewers have no traps, and their gases are blown back by east wind at outlets. 13 Cesspools mainly used. 14 Three-fourths sewage into cesspools, one-fourth into streams and ponds. 15 Discussing a plan of sewers. See Report on Woburn, Winchester, Mystic Pond.

Nine Towns supplied by Aqueduct. Population 3,000 to 5,000.

TOWNS.	Effect on health.	Dwellings.	Dwellings taking water.	Population.	WATER.		SEWERS.	
					Source of Supply and Date of Introduction.	Daily capacity, in gallons.	Total length, in miles.	Where discharged.
Arlington, ¹	None perceptible, .	615	-	3,906	Reservoir on East Lexington meadows. Brook dammed; mainly rainfall, 1874.	-	None, . .	-
Easthampton, ²	None noted, . .	586	-	3,964	Reservoir for fire department.	-	Imperfect system.	Into brook below pond.
Everett, . .	Salutary, . . .	770	-	3,651	Mystic Pond, . . .	-	None for dwellings.	Upon marsh.
Gt. Barrington, ³	Very decidedly good,	839	Every one, .	4,385	Mountain stream, 1871, .	-	None, . .	One-third into Housatonic River.
Hopkinton, .	No definite report, .	768	-	4,503	Private supply for 100 families and two factories, from spring in centre.	-	None, . .	Sewage mainly on surface.
Leominster, ⁴	Too recent, . .	924	-	5,200	Reservoir at foot of Moonstock Mt., 1873.	-	Two street sewers.	Planned to discharge into brook below mills, thence into Nashua River.
South Hadley, .	Recent. No perceptible effect.	502	-	3,370	From brook for South Hadley Falls.	-	None, . .	-
Winchester, ⁵	Too recent. Health always very good.	554	356*	3,099	Rainfall. Reservoir in elevated valley dammed, 1874.	Actual, 800,000; possible, 1,600,000.	None, . .	Natural drainage into Abington River, thence into Mystic Pond.
W. Springfield, ⁶	Not fairly in use yet,	630	12†	3,739	Reservoir on brook, 1875-76.	-	Beginning, .	-
				35,917				

been practicable, certain statistics with regard to each of these towns; viz., the effect of its aqueduct-supply on the general health of its population, the whole number of dwellings, the number of dwellings (sometimes of families) using the water, the population of the town, the source of water-supply and date of introduction, the daily capacity (in United States gallons) of this supply, and, as most closely connected with the free use of water, a few important facts concerning the sewerage of the town; viz., the length (in miles) of its sewers, the place of their final discharge or outfall, and finally brief memoranda indicating the present state of the sewerage question in the town.

For the purpose of facilitating comparison between these towns, they have been arranged in five groups, according to population, giving of those with a population of 20,000 and upwards, 12; from 10,000 to 20,000, 9; from 5,000 to 10,000, 10; from 3,000 to 5,000, 9; less than 3,000, 6.

In proportion as the advantages of aqueducts are appreciated, the importance of preserving our streams and ponds from pollution will be more strongly felt, inasmuch as, with a single exception, to be hereafter mentioned, they afford the only sources for aqueduct-supply. It is to be hoped that the people will be aroused to a jealous care for their preservation before it is too late.

Twenty cities and towns now depend on streams, 16 on great ponds, 7 on springs, 2 towns on "gathering-grounds," and 1 town on ponds and springs.

It is of course understood that all these sources resolve themselves at last into the rainfall, being so many different forms of its reappearance on (or very near) the surface of the ground. Rivers are the open drains; ponds the storage reservoirs; springs smaller forms of the same, fed by a miniature water-shed, sometimes hard by, sometimes farther away, and carried awhile by an underground channel, to reappear as "a spring," or perhaps to be tapped by a well. River or rill, lake or spring, on the surface or subterranean, they are all modifications of this same rainfall, subject to filtration or to pollution from the strata over or through which it finds its way to its natural drains or reservoirs. No person of ordinary intelligence now hopes to secure a water-supply from

the bowels of the earth, which has never been subjected to possible pollution from organic matter.

All our water for domestic and manufacturing purposes must be rainfall, which we are to get as pure as possible; and if we are not speedily and energetically on our guard, we shall be too late to get it wholesomely pure from sewage, the moist refuse of civilized life. By "gathering-grounds" is here meant such reservoirs of primary rainfall as may be made by damming some small valley suitably situated in relation to the community needing the water-supply; a valley into which no stream enters, and where no large pond has a natural existence. The streams of our State are well known. The great ponds are well treated of in the Report of the State Board of Health for 1873, where may be found a list of them, with the size of each. It may be well here to repeat that these ponds comprise one fifty-fourth of the whole territory of Massachusetts, and are public property; also that they are, for the most part, bordered by farms and woodlands, rarely by villages. It is probable that some towns, perhaps many, might make a great pond, in a place suitable for a "gathering-ground," and thus obtain a water-supply with as signal success as has been attained in Winchester.*

As a matter of course a town in deciding upon water-supply becomes alive to the importance of securing perpetual purity for such water, and can understand the immense importance of controlling the water-shed which may supply it, so as to guard against sewage-contamination at the source. And, as the sewerage problem is certain to follow close at the heels of the water question, it is a pertinent inquiry, and one deserving closer attention than it seems to have hitherto received, whether a danger may not arise from the contiguity of sewers and water-mains of thin iron lined with cement.

From the dangers attendant on an intermittent aqueduct supply we are fortunately almost wholly free, every supply reported, with the exception of that of Chicopee, being constant. The dangers of the intermittent system are: 1. The liability when a vacuum occurs in the pipes that sewage or sewage-gas may be sucked into the pipes (main, supply or service). 2. The deterioration of the supply, which under

* See "Winchester," in this Report.

this system must be drawn in advance daily in every dwelling into some receptacle, on account of heating and incipient decomposition.

From the first-named evil several places in England have suffered severely in the form of epidemics of typhoid fever; and several of these have been investigated in the most thorough manner, and the method, place and time of specific contamination have been demonstrated. From the second danger every one who has this kind of supply must suffer, as has been the experience in Chicopee for some years.* Ice can mitigate, but not remedy it.

For further convenience of reference, the towns with aqueduct supply which report any existing system of sewers are classified as draining into "salt-water bays, etc.," into "tidal streams," or into "fresh-water streams."

OUTLETS OF SEWER SYSTEMS OF TOWNS REPORTING ANY SYSTEM.

I.—*Into Salt-water Bays, etc.*

Boston, . . .	Boston Harbor, also into Charles River and other tidal waters.
Fall River, . . .	Mount Hope Bay, partly into Fall River.
Lynn, . . .	Lynn Harbor.
New Bedford, . . .	New Bedford Harbor.
Plymouth, . . .	Plymouth Harbor; outlet bare at low tide.
Salem, . . .	Salem Harbor, North River, Mill Pond.

II.—*Into Tidal Streams.*

Brookline, . . .	Charles River, through Muddy Brook, with tide-gate.
Cambridge, . . .	Charles River (also into Alewife Brook, fresh).
Charlestown, . . .	Charles, Mystic and Miller's rivers.
Chelsea, . . .	Mystic River, Chelsea Creek.
Everett, . . .	Ditches on salt marsh, thence into Mystic River.
Somerville, . . .	Charles River, Mystic River.

III.—*Into Fresh Streams.*

Easthampton, . . .	Brook, below pond.
Fitchburg, . . .	Nashua River.
Great Barrington, . . .	Housatonic River (about one-half).
Haverhill, . . .	Merrimac and Little rivers.
Holyoke, . . .	Connecticut River.
Lawrence, . . .	Merrimac, Spicket and Shawshine rivers.
Leominster, . . .	Brook, which empties into Nashua River.

* See "Chicopee," in this Report.

Lowell, . .	Merrimac and Concord rivers.
Peabody, . .	Procter's and Goldthwaite's brooks.
Pittsfield, . .	Housatonic River, West Branch.
Springfield, . .	Connecticut River.
Worcester, . .	Blackstone River, by Mill Brook.

Of the towns reporting no systems of sewerage, 123 discharge one-half or more of their sewage upon or into the surface; 89 discharge two-thirds or more in this way; nine discharge the whole. There are also 14 large towns or cities where much runs upon the surface, though less than one-fourth of the total sewage of the place. Lists of these classes are subjoined. And following them are lists of towns which report that "such sewage is often or strongly offensive," with a statement in each case as to the observed effect of such emanations on health.

Nine Towns where the Whole Sewage runs on or into the Surface.

Ashfield.	Ipswich.	North Adams.
Danvers.	Mansfield.	Plainfield.
Greenwich.	New Braintree.	Sutton.

Eighty-nine Towns where more than One-half goes on the Surface.

TOWN.	Sewage running on or into surface.	TOWN.	Sewage running on or into surface.
Amesbury, .	Four-fifths.	Chester, . .	Nearly all.
Andover, .	Nearly all.	Colrain, . .	Nearly all.
Ashby, . .	Four-fifths.	Canton, . .	Five-eighths.
Abington, .	Four-fifths.	Concord, . .	73 per cent.
Amherst, .	Three-quarters.	Dover, . . .	Five-eighths.
Barnstable, .	Nearly all.	Dudley, . .	Nearly all.
Belchertown, .	Five-eighths.	Dennis, . .	Two-thirds.
Berkley, . .	Nearly all.	Easthampton, .	Nearly all.
Berlin, . .	Three-quarters.	Eastham, . .	Nearly all.
Blandford, .	Nine-tenths.	E. Bridgewater, .	Nearly all.
Beverly, . .	Very large proportion.	Falmouth, . .	Three-quarters.
Bridgewater, .	Seven-eighths.	Fairhaven, . .	Large proportion.
Brimfield, .	Very large proportion.	Foxborough, . .	Nearly all.
Barre, . . .	Nearly all.	Fall River, . .	Large proportion.
Blackstone, .	Six-tenths.	Fitchburg, . .	Four-fifths.
Braintree, . .	Seven-tenths.	Gt. Barrington, .	Two-thirds.
Brewster, . .	Five-eighths.	Groveland, . .	The most of it.
		Grafton, . . .	Greater part into cesspools.

TOWN.	Sewage running on or into surface.	TOWN.	Sewage running on or into surface.
Harwich, .	Two-thirds.	Raynham, .	More than three-quarters.
Heath, .	Nearly the whole.	Revere, .	Seven-eighths.
Holden, .	More than half.	Rowe, .	Nearly all.
Hardwick, .	Nearly all.	Shelburne, .	Half in the village, seven-eighths among the farmers.
Hopkinton, .	Nearly all.	Shirley, .	Nearly all.
Hadley, .	Nine-tenths.	Shrewsbury, .	Nearly all into sink-holes.
Hudson, .	Nineteen-twenty-fourths.	South Scituate, .	One-third on to surface, one-third into sink-holes, which are the most offensive.
Kingston, .	Nearly all.	Stoughton, .	Three-quarters.
Lunenburg, .	Nearly all.	Swampscott, .	One-half on to surface, one-tenth into cesspools.
Ludlow, .	Five-sixths.	Tewksbury, .	Nearly all.
Littleton, .	Three-quarters.	Tisbury, .	Three-quarters.
Leominster, .	Large part.	Topsfield, .	Nearly all.
Lexington, .	One-half on to surface, three-eighths into cesspools.	Upton, .	Five-eighths.
Middlefield, .	Nine-tenths.	Walpole, .	Four-fifths.
Montague, .	A large part.	Westfield, .	Three-quarters.
Montgomery, .	The largest part.	Westhampton, .	Nearly all.
Marblehead, .	Three-fifths.	W. Brookfield, .	Nearly all.
Mt. Washington, .	Three-quarters.	W. Newbury, .	Nearly all.
Monterey, .	Three-quarters.	W. Stockbridge, .	Three-quarters.
Milford, .	Four-fifths.	Wilbraham, .	A small part on to surface, a large part into cesspools.
Middleborough, .	The larger part.	Winthrop, .	Nearly all.
Medford, .	85 per cent.	Weymouth, .	Seven-tenths.
Nahant, .	Nearly all into cesspools.	Yarmouthport, .	Nearly all.
No. Reading, .	A large part among the farmers.		
Northborough, .	Three-quarters.		
Needham, .	Two-thirds into cesspools.		
Orange, .	Four-fifths.		
Oxford, .	Three-quarters.		
Pembroke, .	Seven-eighths.		
Pepperell, .	Nearly all.		
Randolph, .	Two-thirds into cesspools.		

Twenty-five Towns where between One-quarter and One-half goes on Surface.

TOWN.	Sewage running on or into surface.	TOWN.	Sewage running on or into surface.
Ashburnham, .	One-half.	Huntington, .	One-half.
Brockton, .	One-half.	Hatfield, .	One-half.
Clinton, .	One-half.	Lancaster, .	One-half. [pools.
Enfield, .	About one-half.	Malden, .	One-half in cess-

TOWN.	Sewage running on or into surface.	TOWN.	Sewage running on or into surface.
Medway, .	. One-half.	Sheffield, .	. One-half.
Nantucket, .	. One-half.	Stoneham, .	. One-half.
New Salem, .	. One-half.	Somerset, .	. One-half.
Orleans, .	. One-half.	Wakefield, .	. One-half.
Otis, .	. One-half.	Westborough, .	. One-half. [pools.
Quincy, .	. One-half.	Ware, .	. One-half into cess-
Rockport, .	. One-half.	Webster, .	. One-half.
South Hadley, .	. One-half.	Winchester, .	. Nearly one-half.

Fourteen Large Towns or Cities where Much goes on Surface, though less than One-quarter.

Chicopee.	Lawrence.	Watertown.
Gloucester.	Peabody.	Woburn.
Haverhill.	Springfield.	West Roxbury.
Lowell.	Taunton.	Somerville.
Lynn.	Worcester.	

QUESTION IV.—“*Is such Sewage often or strongly offensive?*”

Eighty-seven of the one hundred and eighty-eight towns answer in the affirmative. Twenty-four report resulting disease. Sixty-five report no disease in this connection. Eight report that such stench* is suspected of causing disease. The diseases reported as resulting are typhoid fever, cerebro-spinal meningitis, diphtheria, typhoid pneumonia, dysentery, diarrhoeal diseases in children, scarlatina. Several observers report “injury to health,” and “increased prevalence of disease,” even where no special diseases are traced to it.

It is a matter of prolonged and common experience among physicians that the poison of several diseases is received more virulently and more speedily through the lungs than through the stomach. Of others we do not positively know that they ever enter the system through the stomach, but we have evidence that they frequently do so through the lungs. And this is precisely what one would expect from the unceasing flow into the lungs of whatever the atmosphere carries, and of its comparatively direct access to the blood within the pulmonary vessels.

It is easy to understand the high death-rate of Boston, when

* This word, as used here and subsequently, includes all emanations associated with the stench.

one observes, on the map of the "Metropolitan District," with this paper, how the city is surrounded with sewer-outlets. It is also easy to understand how any family in the country may create for itself, by means of surface-sewage, as foul an air as is inflicted on the unfortunates who dwell close by the outlet of a great city sewer. Many of the "correspondents" from country towns report the habitual use of dry earth as an absorbent and disinfectant of surface-sewage with the effect of at once saving health and manure, and they bear testimony to the increase of interest and knowledge in regard to sanitary laws among their townsmen. On the other hand, many correspondents report gross ignorance and indifference touching all sanitary matters.

The following lists speak for themselves to a considerable degree, but in studying them, as well as the tables illustrating the subject of polluted drinking-water under the next heads (V. and VI.), it must be borne in mind that the conclusion to be drawn is not that, of the one hundred and seventy-seven returns of wells fouled and frequent stench from surface-sewage, eighty-seven only were associated with disease, but that it was possible to trace distinctly the association of sewage and disease, as cause and effect, in that proportion.

We do not attempt to work out the statistics further, because the necessary data are lacking, and it was not proposed in this paper to collect them; but to avoid misapprehension, we will say that of the above eighty-seven, almost every one represents several instances of disease, many represent tens, some represent scores of instances. Moreover, the medical correspondents do for the most part believe that such connection between filth and disease exists in their practice very much more frequently than they are able to demonstrate. There has been a very marked growth of the scientific spirit of accuracy among physicians, which renders them more and more on their guard about speaking positively in relation to the causation of stated cases of disease which have not been specially investigated. But never was there a time when physicians were so assured that many classes of disease can be prevented by right living, and foremost among the preventable diseases they class those connected with filth.

In this connection the reader is referred to papers in previ-

ous reports of the Board,* and to the lists in the present paper of towns which discharge the greater part of their sewage on the surface; also to the tables of towns with aqueduct-supply in the column headed "Effect on Health," as showing the decrease of typhoid fever where pure water is introduced.

Twenty-one towns report disease from emanations of surface-sewage; nine report typhoid as being so caused; two report diphtheria; one reports meningitis; one reports cholera; one reports pneumonia; one reports dysentery; one reports cholera infantum; one reports scarlatina.

List of Twenty-one Towns reporting Stench from Surface-Sewage, and Resulting Disease.

Chicopee,	. Very offensive stench from factory privies. Typhoid and meningitis.
Charlestown,	. Stench from the various varieties of sewage discharged on flats, bare at low tide, sometimes creates nausea and affects health unfavorably, if not causing special disease.
Haverhill,	. Valley of Little River.
Holyoke,	. Terrible epidemic of typhoid in 1874, when a large and long-used public cesspool was drained off. See Report State Board of Health, 1875 (Health of Towns).
Lowell,	. See Report Board of Health, 1874 (Health of Towns).
Lynn,	. "Many and notable instances."
Lexington,	. Typhoid fever, diphtheria, one case of cholera.
Lawrence,	. Typhoid pneumonia.
Malden,	. Occasionally strong stench, considered dangerous.
Monson,	. Occasionally.
Montague,	. Seven cases typhoid fever, with two deaths in one family from sewage-stench in the cellar.
Plymouth,	. Two cases typhoid fever from sewage in cellar.
Peabody,	. Typhoid fever sometimes traced to stench from sewage on surface.
Pittsfield,	. In some localities.
Quincy,	. In some cases, typhoid.
Salem,	. Intolerable stench and resulting disease.
Springfield,	. Some sewers discharge on river bank with detriment to health.
So. Dennis,	.
Wakefield,	. One very bad locality.
Webster,	. Frequent typhoid and dysentery.

* Causes of Typhoid Fever in Massachusetts, 1871. Mill-Dams and Water Obstructions, 1872. Drainage for Health, 1873. Sewage and Sewerage, 1873. Considerations touching Water-Supply, etc., 1874. Value of Health to the State, 1875.

- Woburn, . Along line of Russell's Brook (see Report of State Board of Health, 1875).
 Worcester, . Cholera infantum, diphtheria, scarlatina.

List of Sixty-five Towns reporting Sewage-Stench WITHOUT Resulting Disease.

Belchertown.	Huntington.	Plainfield.
Beverly.	Hardwick.	Raynham.
Bridgewater.	Harwich.	Rockport.
Brimfield.	Hatfield.	Reading.
Berkley.	Hyde Park.	Randolph.
Barre.	Hudson.	Stoughton.
Blackstone.	Lunenburg.	Shirley.
Braintree.	Ludlow.	Shelburne.
Clinton.	Monterey.	South Scituate.
Canton.	Milford.	Sheffield.
Cambridge.	Middleborough.	Stoneham.
Chelsea.	Medford.	Somerset.
Dudley.	Medway.	Sutton.
Danvers.	Nahant.	Taunton.
Eastham.	Natick.	Upton.
Easton.	North Andover.	Uxbridge.
Falmouth.	North Reading.	Warren.
Fall River.	New Salem.	Weymouth.
Fitchburg.	Newton.	Winchester.
Gardner.	Northampton.	West Stockbridge.
Gilbertville.	Orange.	West Newbury.
Greenwich.*	Pembroke.	

List of Eight Towns reporting Sewage-Stench, and SUSPECTING it of Causing Disease.

Andover.	Charlestown.	Montgomery.
Athol.	Cambridge.	Swampscott.
Arlington.	Fitchburg.	

"QUESTION V.—*Are Wells or other sources of Water-Supply exposed to contamination from Sewage?*"

Of the 188 cities and towns reporting, 90 reply to this question in the affirmative; and of these, 3 send no report of resulting disease; 16 report no resulting disease; 8 are uncertain of resulting disease; 63 report distinct resulting disease.

Of the 63 reporting disease, 44 report typhoid fever; 6

* Strongly offensive.

report dysentery ; 4 report scarlet fever ; 2 report diphtheria ; 2 report cerebro-spinal meningitis ; 11 report simply "disease."

From some of the towns several diseases are reported as probably so caused in each.

List of Towns where the Water for Drinking is more or less Polluted, with Results in Disease, so far as known.

NAME OF TOWN.	Disease.	Amount and Character.	Single or Repeated Cases.	Source of Supply.
Abington, . .	Disease, . .	Occasional, . .	-	Few wells.
Athol, . . .	None, . . .	-	-	Wells.
Ashfield, . .	Meningitis, . .	Serious, . .	One, . . .	One well.
Arlington, . .	Disease, . .	-	-	Few wells.
Amherst, . .	None of late, . .	-	-	Wells often.
Barnstable, . .	Typhoid, . . .	Occasional, . .	-	Wells.
Brighton, . .	" . . .	-	Repeated, . .	Many wells.
Berlin, . . .	Disease, . . .	Serious, . . .	One, . . .	Wells.
Beverly, . . .	Typhoid, . . .	Frequent, . . .	-	"
Brimfield, . .	" . . .	Serious, . . .	One, . . .	"
Brockton, . . .	" . . .	-	Repeated, . .	Wells very bad.
Blackstone, . .	" . . .	-	-	Wells.
Braintree, . .	" . . .	Frequent, . .	Repeated, . .	"
Chicopee, . .	Diarrhœa, . .	" . . .	-	Aqueduct and many wells.
Clinton, . . .	Typhoid, . . .	-	Repeated, . .	Wells.
Canton, . . .	No report, . .	-	-	"
Concord, . . .	Disease, . . .	-	-	Some wells.
Dudley, . . .	Typhoid and dysentery, . .	Frequent, . .	Repeated, . .	Many wells.
Dennis, . . .	Suspected, . .	-	-	Wells possibly.
Danvers, . . .	None, . . .	-	-	Wells exposed.
Easton, . . .	Disease, . . .	Very seldom, . .	-	Some wells.
Fairhaven, . .	" . . .	Fatal, . . .	-	Wells probably.
Foxborough, . .	Probably none, . .	-	-	Wells.
Fall River, . .	Typhoid, . . .	-	-	"
Fitchburg, . .	Enteric and scarlet fevers, . .	-	Repeated, . .	-
Granby, . . .	None, . . .	-	-	Wells.
Greenwich, . .	Typhoid, . . .	-	-	"
Huntington, . .	" . . .	-	-	Wells probably.
Harwich, . . .	" suspected, . .	-	Repeated, . .	Some wells analyzed and thought safe.
Hardwick, . . .	" . . .	-	Large number, . .	Wells.
Hadley, . . .	" . . .	Serious, . . .	Five in one house, . .	Some wells.
Hudson, . . .	" . . .	-	Six in one house, . .	-
Lunenburg, . .	None, . . .	-	-	Few wells.

List of Towns, etc.—Continued.

NAME OF TOWN.	Disease.	Amount and Character.	Single or Repeated Cases.	Source of Supply.
Lowell, . . .	Typhoid, . . .	Frequent and severe.	Repeated, .	Cisterns and wells.
Ludlow, . . .	" . . .	Bad, . . .	"	Wells often.
Leominster, . . .	" . . .	Serious, . . .	Twenty from one well.	One well.
Lynn, . . .	" . . .	Serious and abundant.	—	Wells.
Leverett, . . .	" . . .	Serious, . . .	Whole family,	"
Lexington, . . .	Disease, . . .	—	—	Few wells.
Lawrence, . . .	Typhoid and dysentery.	Sporadic, . . .	Repeated, .	Wells.
Malden, . . .	Typhoid, . . .	—	Several, .	—
Marblehead, . . .	None, . . .	—	—	Few wells.
Mt. Washington, . . .	Enteric fever, . . .	—	—	Wells.
Monterey, . . .	Typhoid, . . .	Occasional, .	—	Some wells.
Mansfield, . . .	None, . . .	—	—	Wells.
Milford, . . .	Typhoid, . . .	Persistent and fatal.	Four from one well.	Water analyzed —not fit to use.
Middleborough, . . .	None, . . .	—	—	Some wells abandoned.
Medford, . . .	Typhoid and meningitis.	Serious, . . .	One, . . .	Few wells.
Medway, . . .	Diphtheria, . . .	Fatal, . . .	Repeated, .	Wells.
Natick, . . .	Doubtful, . . .	—	—	"
Nahant, . . .	Typhoid, . . .	Serious, . . .	One, . . .	"
North Andover, . . .	None, . . .	—	—	"
North Reading, . . .	Typhoid, . . .	—	—	Few wells; very bad.
New Salem, . . .	None, . . .	—	—	Wells.
Newton, . . .	No report, . . .	—	—	"
Needham, . . .	None, . . .	—	—	Wells sometimes.
Orange, . . .	" . . .	—	—	Wells.
Plainfield, . . .	" . . .	—	—	"
Pittsfield, . . .	Typhoid, . . .	Serious, . . .	Repeated, .	"
Quincy, . . .	" . . .	—	—	"
Raynham, . . .	Diarrhœa, . . .	—	—	"
Rockport, . . .	Doubtful, . . .	—	—	Water.
Reading, . . .	Probable, . . .	—	—	Wells.
Randolph, . . .	Disease, . . .	—	—	Water.
Stoughton, . . .	Doubtful, . . .	—	—	Wells often.
Shirley, . . .	Typhoid, . . .	—	Repeated, .	Water.
Stockbridge, . . .	None, . . .	—	—	Few wells.
Shelburne, . . .	" . . .	—	—	Wells.
South Scituate, . . .	Typhoid, . . .	Serious, . . .	One, . . .	"
Shrewsbury, . . .	Low fever, . . .	—	—	Some wells.
Sheffield, . . .	Typhoid, . . .	Occasional, .	Repeated, .	"
Springfield, . . .	Uncertain, . . .	—	—	Water.
Taunton, . . .	Diarrhœa and enteric fever.	—	Repeated, .	Wells.
Upton, . . .	Dysentery and gastritis.	Serious, . . .	Epidemic—9 in one family.	Few wells.
Wakefield, . . .	Typhoid, etc., . . .	" . . .	—	Wells.
Waltham, . . .	" . . .	—	—	Many wells.
Walpole, . . .	" . . .	Serious, . . .	One, . . .	Wells.
Wilmington, . . .	No report, . . .	—	—	"
Worcester, . . .	Typhoid, . . .	—	—	Some wells.

List of Towns, etc.—Concluded.

NAME OF TOWN.	Disease.	Amount and Character.	Single or Repeated Cases.	Source of Supply.
Warren, . .	Typhoid prob- ably.	-	-	Water.
Webster, . .	Doubtful, . .	-	-	Wells often.
Wrentham, . .	Uncertain, . .	-	-	Some wells.
Weymouth, . .	Disease, . .	Rare, . .	-	Few wells.
Watertown, . .	" . .	Very little, . .	-	Wells probably.
Westborough, . .	Diphtheria and scarlet fever.	Serious, . .	Family of 7, 4 died.	Few wells.
Winchester, . .	Typhoid, none of late.	Very rare, . .	Two in one family.	Wells rarely.
Woburn, . .	Typhoid, . .	-	Repeated, . .	Water.
West Newbury, . .	" etc., . .	-	Two, . .	Wells probably.
West Roxbury, . .	" . .	-	-	Many wells.

Of these 90 towns reporting *polluted drinking-water*, 3 send no report of disease; 16 report "no disease"; 8 report "doubtful"; 63 report disease.

Of these 63 reporting disease, 44 report typhoid; 2 report meningitis; 2 report diphtheria; 6 report dysentery, etc.; 5 report scarlet and other fevers; 11 report "disease," without specifying the kind.

"QUESTION VII.—*If any water-courses or ponds are used to receive sewage from manufactories or other sources in your town (or city), will you please give some account of them?*

"(a.) *As to pollution of drinking-water.*

"(b.) *As to pollution of the atmosphere, either by emanations from the contaminated water, or from flats, docks, banks of streams, etc.*

"(c.) *As to the effect of converting small streams into covered sewers.*

"(d.) *Any other facts that may occur to you.*"

Under this head 88 towns report, of which 42 appear to be more or less completely satisfied with this disposal of their sewage, while 46 regard it as objectionable and to be remedied as soon as possible. Lists of the two classes are subjoined. It will be observed that a few towns appear in both lists; *e. g.*, Fitchburg uses Nashua River as a receptacle for sewage without dissatisfaction, but is planning a

better method of dealing with Punch Brook; Somerville is satisfied thus to use Mystic River, but not Charles River or Alewife Brook.

From the following lists some idea may be formed in regard to the frequency and degree of pollution of streams and ponds in the Commonwealth. But it must be understood that these lists include but 169 of the 322 towns in Massachusetts, 153 having failed to report. Of the 19 cities every one made its return. The population of the places reporting amounts to 84 per cent. of the whole population. There would be no significance in indicating the population of each town on the lists, because we cannot in most instances state what proportion of the sewage gets into the stream in question. For convenience of reference another list is furnished in which the streams appear first, with the towns draining and sewerage into each, so far as the writer has been able to ascertain from his line of investigation. It is evident that this danger is rapidly growing upon us, and that its future ratio of increase will be much greater; not only because population will become more concentrated, as well as actually greater, but because of a growing desire for aqueduct supply and its attendant "water-carriage" of sewage. It is gratifying to know that the objections to this fouling are felt in more than half the instances recorded, and that this fraction represents a very much larger proportion of the voters concerned.

Towns reporting Streams or Ponds used to receive Sewage to the
SATISFACTION of parties concerned.

TOWNS.	Stream.	Source of Sewage.
Attleborough, . .	"Ten Mile River," . .	Certain factories.
Amesbury, . . .	Powow River, ¹ . . .	Certain factories.
Athol, ...	Small, swift streams, .	One-tenth of sewage.
Belmont, ...	Two rapid brooks.	
Chicopee, ...	Connecticut River, . .	By way of canal and Chicopee River.
Clinton, ...	Nashua River (South Branch). ²	Gas and dye works.

¹ Has a good fall, and tidal wash.

² Fish killed two miles below.

Towns reporting Streams, etc.—Continued.

TOWNS.	Stream.	Source of Sewage.
Easthampton, .	Manhan River.	
Everett, .		
E. Bridgewater, .	Matfield River.	
Foxborough, .	Cocasset River, . .	Several factories.
Fall River, .	"Fall River," ¹ . .	Twelve large factories.
Fitchburg, .	Nashua River, ² . .	Large part.
Great Barrington,	Housatonic River.	
Gardner, .	Small streams.	
Hyde Park, .	Neponset River, . .	Factories.
Hingham, .	Tidal mill pond on town brook	Small dye-house.
Ipswich, .	Ipswich River, ³ . .	Manufactories.
Lowell, .	Concord and Merrimac rivers.	Large part.
Leominster, .	Monoosneck Brook, thence into Nashua R.	
Lancaster, .	Nashua River, . .	One factory of shoe- shanks.
Lawrence, .	Merrimac River, ⁴ . .	Many factories and some city sewers
Middleborough, .	Namasket River, . .	Manufactories.
Newburyport, .	Merrimac River to sea, .	Everything.
North Adams, .	"Rapid stream," . .	Everything.
Oxford, .	"Stream,"	Woolen and cotton fac- tories.
Palmer, .	"Rivers,"	Factories and families.
Pittsfield, .	Housatonic River, . .	Factories and a few tene- ments.
Stockbridge, .	Housatonic River, . .	Paper and "pulp" fac- tories.
Shelburne, .	Brook, and thence Deer- field River.	Factory, stables, etc.
South Hadley, .	Connecticut River, . .	Large factories and paper mills.
Sudbury, .	"Stream," thence Sud- bury River.	From two factories.
Tyringham, .	"Small, rapid stream," .	Everything.
W. Springfield, .	Agawam River, . . .	Mills.
Waltham, .	Charles River, . . .	Two factories.
Walpole, .	Neponset River, . . .	Factories and mills.
Ware, .	Ware River, ...	Factories.
Warren, .	Quaboag River, ⁷ . . .	Six factories.
Westhampton, .	Brook, ...	One tannery.
Wrentham, .	By Mill Brook into Charles R. in Medway.	"Two water-powers."
Wilbraham, .	"Streams,"	"Manufactories."

¹ "Rapid fall to harbor."² Close by city, river much discolored; no stench.³ "Nothing could be better."⁴ Large, rapid, and scoured yearly by freshets.⁵ Rapid river.

Towns reporting Streams (and Ponds) receiving Sewage to the
DISSATISFACTION of parties concerned.

TOWNS.	Stream.	Source of Sewage.
Blandford, . . .	Branch of Westfield R., ¹	Two tanneries.
Brookline, . . .	Muddy Creek, ²	Sewers.
Blackstone, . . .	Blackstone River, ³	One-fifth sewage.
Colrain, . . .	Pond, ⁴	Sewage of thirty families.
Charlestown, . . .	Mystic, Charles and Miller's rivers. ⁵	Everything.
Cambridge, . . .	Charles River and Alewife Brook ⁶	Everything.
Chester, . . .	W. Branch Westfield R.	Tannery.
Concord, . . .	Branch of Concord R., .	About one-twentieth.
Dover, . . .	Charles River, . . .	Paper mill.
Dudley, . . .	French River, . . .	"Some sewage."
Danvers, . . .	Essex River (tidal), .	Gas factory.
Fairhaven, . . .	Saltwater Pond, ⁷	Sewage.
Foxborough, . . .	Cocasset River into Wading River.	"Many factories, etc."
Fitchburg, . . .	Punch Brook, ⁸	Much filth.
Groveland, . . .	"Stream below fall" running into Merrimac R. ⁹	Wash from wool and other factories.
Haverhill, . . .	Merrimac and Little R's, ¹⁰	Everything.
Hardwick, . . .	Pond in Gilbertville, .	Mills.
Ludlow, . . .	Chicopee River, . . .	Partly through High Brook.
Lynn, . . .	Strawberry Brook, Stacey's Brook, Silver Lake, Flax Pond Marshes, Flats of harbor.	Everything.
Leominster, . . .	Brook in N. Leominster, ¹¹	Tannery.
Lexington, . . .	Vine Brook, . . .	Slaughter house.
Monson, . . .	Brook, . . .	Several woolen mills.
Middlefield, . . .	Branch of Westfield R., ¹²	"One factory, two mills."
Natick, . . .	Pegan Brook, thence to Lake Cochituate.	Factories, tannery, water-closets, dwellings.
Newton, . . .	Charles River, . . .	Manufactories.
Northampton, . . .	"Streams," thence into Mill River. ¹³	
Orleans, . . .	Sluggish tidal stream.	
Orange, . . .	Pond, . . .	Much sewage.
Plymouth, . . .	Mill Pond, ¹⁴	Much sewage.

¹ "Fish killed for half a mile below."

² With tide-gate, increases pollution of "Back Bay."

³ Stench when river is low.

⁴ Stench and disease from the fouled banks in dry seasons.

⁵ Flats saturated with filth.

⁶ The former objectionable to Cambridge, Boston and Charlestown; the latter to Medford.

⁷ "Trouble expected."

⁸ Small stream through dense population, empties into Nashua River.

⁹ Much fouled.

¹⁰ Latter very bad.

¹¹ For $\frac{1}{2}$ mile offensive.

¹² "Fish killed."

¹³ Filthy in droughts.

¹⁴ Offensive.

Towns reporting Streams, etc.—Continued.

TOWNS.	Stream.	Source of Sewage.
Peabody, . .	Procter's Brook, ¹ . .	All kinds of leather factories; some dwellings.
Pittsfield, . .	Silver Lake by brook, ² . .	Factory.
Stoneham, . .	Mill Brook to Mystic head. ³	Tanneries and 40 per cent. of town sewage.
Springfield, . .	Connecticut River, . .	Sewers.
Salem, . .	North River; part of Mill pond. ⁴	Worst kind, and in great amount.
Somerville, . .	Charles River, etc., ⁵ . .	City sewers.
Taunton, . .	Taunton River, . .	Sewers and factories.
Wakefield, . .	Saugus River, . .	Privies of rattan factory, 1,000 operatives at times.
West Brookfield, .	Large pond and Quaboag River.	
Worcester, . .	Blackstone River, . .	Everything.
Webster, . .	French River, . .	All the factories.
Watertown, . .	Charles River, . .	All the factories, and town must drain same way.
Winchester, . .	Head waters of Mystic Pond. ⁶	Five tanneries, a wool-washing place, and a number of dwellings.
Woburn, . .	Brooks emptying in head waters of Mystic Pond, ⁷	Leather-shops, and much else.
W. Stockbridge, .	Shaker Mill Pond and Williams River. ⁸	

¹ Discharges into North River in Salem.² Ice-supply for the town; analysis shows brook and lake, near its mouth, to be perceptibly fouled.³ Horses will not drink waters; fish have disappeared.⁴ "A shocking and dangerous nuisance."⁵ In same category with Cambridge and Charlestown.⁶ A great amount of filth, and often offensive.⁷ Air and water fouled.⁸ Offensive at low water.*List of Streams and Ponds reported as receiving Sewage.*

Streams.	Towns Sewering into.
Agawam River, . . .	West Springfield.
Alewife Brook, . . .	Cambridge.
Blackstone River, . . .	Blackstone.
" " . . .	Worcester.
Charles River, . . .	Boston.
" " . . .	Brighton.
" " . . .	Brookline, through Muddy Brook, with tide-gate.
" " . . .	Cambridge.
" " . . .	Charlestown.
" " . . .	Dover.

Streams.	Towns Sewering into.
Charles River, . . .	. Newton.
“ “ . . .	. Somerville.
“ “ . . .	. Waltham.
“ “ . . .	. Watertown.
“ “ . . .	. Wrentham, through Mill Brook.
Chicopee River, . . .	. Ludlow, through Higher Brook.
Cocasset River, . . .	. Foxborough.
Concord River, . . .	. Lowell.
“ “ . . .	. Concord, through branches.
Connecticut River, . . .	. Chicopee.
“ “ . . .	. East Hadley.
“ “ . . .	. Holyoke.
“ “ . . .	. Springfield.
Deerfield River, . . .	. Shelburne, through streams.
Essex River, . . .	. Danvers.
Fall River, . . .	. Fall River.
French River, . . .	. Dudley.
“ “ . . .	. Webster.
Housatonic River, . . .	. Great Barrington.
“ “ . . .	. Stockbridge.
“ “ . . .	. Pittsfield.
Ipswich River, . . .	. Ipswich.
Little River, . . .	. Haverhill.
Manhan River, . . .	. Easthampton.
Matfield River, . . .	. East Bridgewater.
Merrimac River, . . .	. Groveland, through stream.
“ “ . . .	. Haverhill.
“ “ . . .	. Lawrence.
“ “ . . .	. Lowell.
“ “ . . .	. Newburyport.
Miller's River, . . .	. Charlestown.
“ “ . . .	. East Cambridge.
Mystic River, . . .	. Charlestown.
“ “ . . .	. Everett.
“ “ . . .	. Medford.
“ “ . . .	. Somerville.
Nashua River, . . .	. Clinton.
“ “ . . .	. Fitchburg.
“ “ . . .	. Lancaster.
“ “ . . .	. Leominster, through Monoosneck Brook.
Namasket River, . . .	. Middleborough.
Neponset River, . . .	. Hyde Park.
“ “ . . .	. Walpole.
North River, . . .	. Peabody, through Procter's Brook.
“ “ . . .	. Salem.
Powow River, . . .	. Amesbury.
Punch Brook, . . .	. Fitchburg.
Quaboag River, . . .	. West Brookfield.

Streams.	Towns Sewering into.
Saugus River, . . .	Wakefield.
Stacey's Brook, . . .	Lynn.
Stony Brook, . . .	"
Strawberry Brook, . . .	"
Sudbury River, . . .	Sudbury, through streams.
Taunton River, . . .	Taunton.
Ten Mile River, . . .	Attleborough.
Vine Brook, . . .	Lexington.
Ware River, . . .	Ware.
Westfield River, . . .	Blandford.
" " West Branch,	Chester.
" " " "	Middlefield.
Williams River, . . .	West Stockbridge.

Ponds receiving Sewage, together with names of Towns which put them to such use.

<i>Ponds — tidal.</i>	Names of	{ Fairhaven.
ponds not given in returns,		{ Hingham.
		{ Salem.

Ponds—fresh.

Cochituate Pond, . . .	Natick, through Pegan Brook.
Flax Pond, . . .	Lynn.
Little Pond, . . .	Braintree.
Mystic Pond, . . .	Stoneham, through stream.
" " . . .	Winchester, through stream.
" " . . .	Woburn, through stream.
Shaker Pond, . . .	West Stockbridge.
Silver Lake, . . .	Lynn.
Silver Lake, . . .	Pittsfield.

Names of ponds not given	{ Colrain.
in returns, . . .	{ Hardwick.
	{ Orange.
	{ Plymouth.
	{ West Brookfield.

In the report by Mr. Kirkwood will be found very valuable and full information in regard to the volume and character of the waters of the Chicopee, Blackstone, Taunton, Charles and Neponset rivers, including detailed accounts of the position and business of all manufactories on these streams and their tributaries, as well as the character and volume of their sewage. In the same paper there is contained so much information in regard to certain English streams, and their effect on populations using them as water-supplies, as to render it unnecessary to enter upon that comparison in this paper. And

to this same report by Mr. Kirkwood (Part III. General Conclusions) the reader is referred for matter pertinent to the general question of pollution of streams and ponds by sewage.

There are three points, a clear understanding of which is so important to the public, that they may well be stated and emphasized again and again in this Report.

1. Chemical analysis, though a very valuable means of ascertaining the quality of water, is not alone sufficient. Especially it may fail to detect organic impurity in a water which is carrying the poison of typhoid fever or of cholera, an incredibly small amount of which is sometimes sufficient to set up the specific morbid action of those diseases in persons receiving said poison in their drinking-water.

2. A water-supply whose quality is *somewhat* deteriorated by the constant admixture of sewage, but not to such a degree as to lead the chemist to *condemn* it, or to cause distinct disease or increased death-rate among its consumers, may yet gradually and insidiously lower their vigor, so that when the time comes—as come it must in the case of streams which receive sewage from privies and water-closets—that some of the above-mentioned evacuations enter a water-supply, the zymotic poison then conveyed to the damaged constitutions of those using it will find them prepared to yield to the morbid influence, as the feeble and sickly everywhere succumb to disease which stronger and healthier constitutions resist successfully.

3. In cases where it may be impossible to discharge the sewage of a large town elsewhere than into the body of water furnishing the supply of the town, it should be strictly forbidden to discharge any *excrement* into the sewers.* Thus much can at least be effected, and it is the most important safeguard of all. It has been shown, under the head of "Excrement-Removal," that such exclusion is perfectly practicable and consistent with strict cleanliness and economy; and in the case supposed, a town might well forego the convenience of water-closets for the sake of safety from zymotic epidemics.

* The cases are probably very few, if there are indeed any such in our State, where *some* means cannot be devised of keeping all filth out of streams or ponds used for domestic purposes.

"(a.) *As to pollution of drinking-water.*"

The answers show that many correspondents misapprehended the scope of this question, and supposed it meant to cover every case of polluted drinking-water in their town; but, from data furnished by those who took the true meaning, it may be said that cases of such pollution as the question covers are rare, and that most of those which occur affect the drinking-water of other towns, rather than of that where the sewage enters the stream or pond. They may be looked for under Question IX.

"(b.) *As to pollution of the atmosphere, either by emanations from the contaminated water, or from flats, docks, banks of streams, etc.*

Nineteen instances of this kind are reported, all of which have already been given in the preceding lists, and the more important of which are detailed under special reports, or under III. and IX. It is worthy of notice that the evil in question is found almost entirely in the cities and large towns, where it is often very serious, and only to be remedied at immense expense; a fact which all growing communities may well note, and learn from it to take in hand their nuisances while yet manageable at moderate cost.

Many of these streams used as open sewers are most emphatically mentioned as being sources of very serious nuisance.

"(c.) *As to the effect of converting small streams into covered sewers.*"

Experience on this point is rare, there being but twelve instances reported, and the testimony of these seeming to conflict to some degree; but it is believed that closer examination would harmonize these discrepancies. This method is on trial at—

Chicopee, . .	Result too recent to judge.
Everett, . .	" favorable.
Lowell, . .	" two inconsiderable instances; considered a bad practice.
Natick, . .	" Pegan Brook for part of its course.
Newton, . .	" perhaps favorable.
Peabody, . .	" favorable on the whole.

Salem, . . .	Result very unfavorable.
Shelburne Falls, . . .	" favorable.
Springfield, . . .	" unfavorable.
Wakefield, . . .	" very unfavorable.
Woburn, . . .	" favorable.
Worcester, . . .	" good, if enough flow of water at all times.

New Bedford reports Tripp's Brook as so treated, but it would seem rather to be a case where a small stream is run for a considerable distance ($1\frac{1}{8}$ miles) through well-constructed sewers, and before and after it enters these, is simply an open stream used as a sewer. The part of the city where it is in the latter state is thinly peopled, and the arrangement has been satisfactory. Pittsfield reports a similar case on a larger scale, with improvement to the health of the neighborhood.

In Salem, in 1874, there occurred a painful illustration of the dangers incident to the expedient now under consideration whenever it is carelessly adopted. As the whole story is given in detail in the Report of the Board for 1875 (p. 348), it is unnecessary to repeat here more than its main features, viz.: For about half a century a small water-course had been used as a drain and sewer for certain streets; and, as it traversed many back yards, and passed directly under one dwelling, it was walled and covered as suited the ideas of each householder,—with stone, with wood or with both, always loosely built,—that it might the better serve the purpose of a drain. On Norman Street (nearly a quarter of a mile from its beginning) it turned a right angle as it passed between two dwellings three feet apart, and there (after remaining open for many years), it was, about twenty years ago, covered by the city with plank at the petition of the abutters. On the decay of the plank, it was re-covered with flagstones, having loose joints. The bottom of the drain at this point was a foot below the earthen floor of the cellars. The *cellar walls of loose stones formed its sides*. Its covering was hardly concealed with earth. In the course of time, the streets above Norman Street were supplied with proper sewers, and it was proposed to continue the trunk line down Norman Street, but the city would not assume the whole expense, and the abutters were unwilling to be assessed on its account. For "economy," therefore, all the sewage and drainage from

the new sewers above was made to enter the "small stream, converted into a covered sewer," as above described. The outlet of the sewer being "tide-locked," the gases were, at certain hours of each day, under strong outward pressure, and escaped freely between the loose covering-stones. Upon complaint from the tenants of the two houses between which the rectangular turn occurs, the city cemented the loose joints of the covering, a proceeding which could result only in forcing sewer-gas in greater quantities through the loose cellar walls which formed the sides of the sewer. Then came the death of the son and daughter of the tenant of one of the houses. Upon this, the city lined the interior of this cellar wall with brick and cement, but did nothing to the floor; and at the time of reporting, in 1874, no steps had been taken toward laying a proper sewer in the street. This has now been done, however.

Since the time, in 1869, when the flow from the new sewers above was turned into the Norman Street water-course, and up to date of reporting, in 1874, twelve cases of typhoid fever occurred within two hundred and fifty feet of this "water-course converted into a covered sewer."

With this instance from one of our oldest cities, may be compared the following account from the correspondent of the board in Wakefield (formerly South Reading):—

"A 'covered stream used as a sewer,' in our town, is so much a sewer, that it is doubtful if it ought to be called a stream, unless it be a stream of filth,—a very grievous source of danger, disease and discomfort, not easy to deal with, almost impossible to abolish, except at great expense, and not lessening, but increasing, with growth of population. The stream was originally the product of the gathered waters of quite a little water-shed, which, finding a boggy basin at the head of the little 'run' through which the stream passes, undoubtedly in the early days 'ponded' there, and made a swamp spot, whose weep and overflow gradually worked its way down this little ravine, a clear rill, receiving the land-wash as it went, till it met, as now (only then comparatively pure), the outfall stream of Crystal Lake, within a rod or two of our present Centre Depot, and commingling with that passed on through the meadows to Saugus River. The little swampy basin that was the 'head waters' of this stream, chanced to fall within the purchase of a

wealthy gentleman, who dug it out, and stoned it about for a fish-pond, and drained into it the surrounding land.

"This pond is now the principal source (secondary) of this stream, (of course the land side was and is the original); and across the stream, after it leaves the pond, there have been thrown four streets, while three stables have been built *over* it in its course, and it is now (beside the streets and buildings) covered in its passage through private grounds for a distance of nearly one-eighth of a mile. It was formerly covered through private land some forty or fifty rods more, but its stoned-up walls caved in, being too narrow bounds for its frequent volume, its leach became a general nuisance, demanding attention, and it was finally reopened and increased in width, and now remains open. Where now closed it has been covered with flag-stones, and from a foot to three feet of earth.

"The stream not only surface-drains quite a large and very populous area, but receives, for its length, a very large number of ditches, drains, cesspool overflows, stable-cellar leachings and vault-soak-ages, beside the street-wash, hogpen-filth, etc., of its 'line of march.'

"When on the board of health two years ago, I made a careful study of the stream, and endeavored to devise plans whereby its dangers and annoyances might be at least mitigated. All I could do was to remove, so far as possible, all incoming sources of filth, as hogpens, privy-vaults, sink-drains and swill from immediate contact, though, as you will readily perceive, I could not but recognize that the removed privy-vaults, etc., would soon send their contents percolating through the small amount of intervening soil to the stream again.

"Wherever the stream has been covered, it has frequently clogged and 'backed up' into drains and yards, forcing its gases into such houses as were connected by tight pipes with it, and making a general nuisance. On my formerly frequent night rounds, as health officer, the line of this stream almost always greeted me with a cloud of dank moisture, and occasionally with a mouldy, sickly smell, like that of some of the fungi. I have ever regarded it as one of the chief agents of disease in our midst, and have taken some pains to ascertain in regard to the health of its adjoining neighbors during the last five years."

A specimen from this brook sent for analysis was very foul throughout. It is shown by the following table to be very largely contaminated with filth; much more so, indeed, than many specimens of sewage examined by Prof. Nichols for the Fourth Report of the State Board of Health.

	Results expressed parts per 100,000.
Ammonia, ...	0.3600
"Albuminoid ammonia,"	0.2000
Inorganic matter, ...	49.28
"Organic and volatile matter,"	9.40
Total solid residue at 212° Fahr., ...	58.68
Chlorine, ...	6.04

It is interesting to compare with the experience of Salem and Wakefield that of Peabody (formerly South Danvers), where, for many years, a vast amount of sewage of the worst description has been poured into a stream traversing the very centre of the town, covered for considerable distances at several points, and making some sharp turns in its course. The walls of this stream converted into a sewer are in some places formed by the foundations of buildings. There is a distinct stench from it, but this is never made a ground of complaint to the local authorities. In the experience of a physician in active practice there for more than a dozen years, and in that of his father also, who for at least a quarter of a century practised medicine there, no especial prevalence of disease of any kind has been observed in the many dwellings and business buildings along the course of this polluted stream. The explanation of this is to be found in the volume and constancy of the stream, in the size and openness of its bed (for even along its covered portions air circulates freely), and in the attention paid to prevent accumulations of filth in its course. It is cleansed twice a year. Something may be attributed to the various astringents and mineral disinfectants pouring in with the sewage, but these are of no avail in the neighboring city of Salem, and must exert in Peabody an influence much inferior to that of the causes just enumerated. It will be observed that split-granite and mortar—not loose-jointed stones—form the foundations of the few buildings which wall the stream.

A detailed description of this brook, and the evils incident

to its pollution, are given in the following extracts from the replies to our circulars.

ACCOUNT OF PROCTER'S BROOK IN PEABODY.

"A few families, near a brook which divides the town nearly equally as to population, etc., lead their drains into it. This brook is the natural sewer of the town, and without it the principal industries of the place could not be carried on. It answers its purpose admirably well, for even in the driest weather there is always a sufficient flow of water to keep the channel clear. It flows through all the settled portion of the town, in a stone-walled brook, about fifteen feet wide, partially covered, and partially open; is crooked in its course, and is made to turn several right angles in the very centre of the town. The sewage of manufactories is discharged almost entirely into this brook. These manufactories consist of between twenty and twenty-five tanneries, three glue factories, seven morocco factories, and one bleachery of cotton cloth. The sewage from the tanneries and the morocco factories is mainly the water from the 'soaks,' so called, or vats in which the raw hides, skins, etc., are washed and softened. This water necessarily contains much putrefactive matter, and is strong-smelling, but some disinfecting power is exerted by the lime which is used, and which also is poured into the brook.

"The sewage of the glue factories is deprived of the most of its solid constituents, and when it reaches the brook it consists of very dirty-looking and strong-smelling water. Fortunately, the bleachery, which is situated just below the glue factories, pours into the brook large quantities of copperas, logwood, cutch, gambia, chloride of lime, etc., in solution, which, though discoloring the water, do not render it offensive to the smell. On the contrary, it has been remarked that the brook below the bleachery is not so offensive as it is above, where it is fouled by the sewage of the glue factories, as above stated.

"It will be seen that this brook contains considerable putrefactive matter, and in hot summer days the smell is certainly offensive near its course. That it is not more so is accounted for by the facts that it is a constantly moving current, and that much disinfecting and deodorizing material is also circulating in its waters. Twice a year, too, when the water is low, the local board of health have its channel raked over, and then flushed from the dam above, near the bleachery. It is checked in its course at several points, as above at the bleachery, and principally again at Frye's mills in Salem. The effect of this latter dam is to overflow into a pond of some acres the

low lands extending for an eighth of a mile above. It is here that the major part of the solid material must be deposited ; yet it is the testimony of near residents that no odor is perceptible, except at such times as the water has been run off, as is occasionally done, leaving the bed of the pond naked. Below this dam extensive tanneries and other manufactories, as well as some of the Salem city sewers, empty their sewage upon flats, which, when bare at low water, emit a stench in hot summer nights which is carried to points at considerable distance, and over a thickly settled portion of the city of Salem.

“In answer to Question IV. (Is such sewage often or strongly offensive?), it may be said that to occupants of houses situated directly on the borders of the brook or canal in its course through the town of Peabody, the odor arising from it during the summer months is offensive, and sometimes strongly so ; and yet, as a member of the local board of health for seven years, I do not recollect of a single complaint ; very possibly because it has been looked upon as a necessary evil. The smell, however, cannot be carried very far, as it never has been perceptible in my own residence, though the latter is situated within three or four hundred feet of an open portion of the brook.

“I think there are no wells used for domestic purposes within such proximity to the brook as to incur the danger of contamination.”

In answer to certain questions, the following additional information was furnished :—

“The walls of the stream, or streams, passing through Peabody are stoned up with rubble-stone, mostly, though in some places split-granite has been used, but no mortar, except where, as in some cases, the foundation of a building forms the wall of the channel.*

“There are several places in the course of this stream where buildings have been erected immediately over its course, and one is used as a boarding-house, in which are a dozen or more boarders. No unusual sickness ever occurred in the house, to my knowledge.

“Below Grove Street, a large space is overflowed by water, and forms the pond mentioned in my report. At the present writing, it has been run off, and I see the bed of the stream is very black and foul.”

From considerations of convenience and decency, the change from the open to the covered condition of small

* Compare the map of Salem and Peabody, page 259.

streams which are constantly receiving offensive sewage, is pretty certain to occur, and it is therefore of great importance that the sanitary aspect of the change should be familiarly known. It may be stated as follows:—

All the unwholesome conditions existing in open streams polluted by sewage remain unchanged when such streams are simply covered, or when they are covered and walled with material of an absorbent or permeable character—as wood, brick or stone, without good cement. They even become more dangerous as generators and conductors of sewage-gas, because they admit air far less freely; consequently their gases are less diluted and more poisonous. At the same time, being less conspicuous, or even out of sight, they may insidiously deliver their poisonous gases within dwellings, or in close neighborhood to windows. And further, such streams, even if suitably covered and walled, may, if their bottoms are left unchanged to absorb and at the same time to retain the commingling sewage, continue to contaminate the earth through which they flow, with the effect of polluting all neighboring wells, and rendering the soil along their banks unsafe foundation for dwellings. The transformation into “covered sewers” can be made safely only by changing them into *complete* sewers. In this case, great care must be taken that proper drainage of the soil is also maintained. Whenever the demands of an increasing population require that streams should be converted into sewers (an evil which should be avoided, if possible), it is not often possible for a single conduit to serve both purposes of sewer and drain. The only thoroughly satisfactory method is to have a tight sewer for the sewage, and beside that a loose-walled drain to carry off the moisture from the soil.

The following account, from Chicopee, shows the benefit which may, in some cases, arise from converting into a well-built sewer a stream which had become so fouled as to be practically simply an open conduit for sewage:—

“On the south-east border of our village is an elevated ridge of land, the water from which nearly all gathers into a water-course which runs across the south-westerly portion of the village, into the Connecticut River, a short distance below its junction with the

Chicopee. In this course it runs through an open square or 'common,' about fifteen rods across, which is bounded on all sides by dwelling-houses, standing so near each other that there is but one chance of putting in another. This water-course, a large portion of the year, had more or less water running in it. In the very driest season it would occasionally be partially dry, but nearly always muddy, even then. In spring, or wet weather, quite a brook ran through the course. Last summer the whole was made into a brick sewer, apparently substantially built. This sewer formerly was covered through part of its length only, and was left open for some fifteen or more rods through a sort of ravine, before reaching the Connecticut River. Many complaints were made about this open piece of sewer, and I have no doubt much sickness was caused by it. At the time the water-course was converted into a sewer, with brick walls, this open tract was also built up and covered, and the ravine was cleared of pigpens, and all other sources of filth, except privies. Blocks of tenement-houses now occupy each side of the ravine. I have little doubt that this improvement has conduced very much to the health of the population in this neighborhood, as we have had less fever, dysentery and spinal meningitis, etc., than in any autumn for many years. The sanitary conditions of this section are so far very satisfactory. While fever and diphtheritic diseases have prevailed in towns adjoining us, we have been remarkably exempt all through the present autumn."

"QUESTION VIII.—*Have you in your town (or city), damp or wet cellars?*"

One hundred and twenty-eight towns report many damp or wet cellars; ninety-seven find this condition productive of disease; thirty-one do not.

The class of diseases most frequently noted in connection with such cellars is "inflammatory diseases of the respiratory organs" especially bronchitis. Next in order of frequency comes rheumatism, more particularly of the sub-acute order. Phthisis, pneumonia, and wasting chronic perversions of digestion are also found by many of our correspondents to be common over such cellars. Also a lessened power of resistance to all diseases when contracted. No observer can doubt that a large amount of preventable disease is caused by damp cellars. The remedy for this evil is admirably set forth in a paper on "Drainage for Health" by Hon. H. F. French.* A good

* Fourth Report of the State Board of Health, p. 182.

system of sewerage very generally cures the evil, and no town which has reasonable expectations of ever needing sewerage should allow any dwelling to be built at an undrainable grade. How many cities in Massachusetts are groaning to-day under the evils and expenses brought upon them by the short-sighted policy of permitting such cellars to be made.

Even where population seems destined to remain small and widely scattered, public opinion should insist on the necessity of good drainage for every dwelling. No town can afford to have house after house built with no provision for keeping the ground beneath it dry, and so far maintaining the health and producing power of its inhabitants. If we had enlightened local boards of health, ordinances would soon become common which would require that every new dwelling should be examined and approved by a health official as to this requirement of drainage, before it could be inhabited. The expense of securing proper drainage is small—except in localities altogether unfit for habitations—and the return in exemption from disease is unspeakably valuable.

In some of the very low-lying towns of the State, drains are very much needed to relieve large tracts of land, including many dwellings, from the excessive soil-moisture. Individual action in these cases is generally of little avail, and the only effectual remedy is in the construction of proper drains by the town authorities.

"QUESTION IX.—Do you know of any case where the sewage of one town pollutes the air or water of another? If so, please state circumstances."

In answer to this question, fifteen cities and towns replied in the affirmative.

In Wakefield, the filth discharged into the brook running through the town, finally finds its way, at least a considerable portion of it, into the Saugus River, from which Lynn has proposed taking part of its water-supply.

Our correspondent in Natick says that "the sewage of Natick must soon seriously pollute the water-supply of Boston."

The banks of the Sudbury River, above the point from which the supply for Boston is to be taken, need protection

with reference to preventing any pollution, which otherwise must inevitably occur.

In the Mystic water-shed, there are serious evils which will be pointed out in detail at a later page.

The Merrimac River, above Lowell, is polluted by the sewage of Manchester, and of several smaller towns in New Hampshire; before reaching Lawrence, the sewage of Lowell, and a considerable amount of filth brought down by the Concord River, have been added. Haverhill, still lower down, gets the benefit also of the sewage of Lawrence, together with the refuse discharged into the Merrimac by the Shawshine and Spicket rivers, the latter of which, in summer, is rendered quite offensive by the filth from manufactories. The cities on the Merrimac River have not yet introduced complete sewerage systems. The volume of the stream, too, is so great, and its current is so rapid, that the impurities in the river just above Lowell, Lawrence or Haverhill are hardly appreciable to the chemist. Mr. Henry F. Mills, C. E., of Lawrence, says: "The Merrimac River flows through the middle of the territory of the city, with a quantity of water varying yearly from 60,000 cubic feet of water per second, with an occasional year increasing to 90,000 cubic feet per second. The water falls here about thirty feet. Below the dam, where all sewage enters, the banks of the river are covered with silt or fine sand to the depth of a foot or more, during heavy freshets; and, as the surface of the water settles with the decrease in the quantity of water, this new lining of the bed is carried away. Thus, there is a continual renewal of the bed of the river from season to season; that is, a deposition and its removal without materially changing the level of the bed from year to year. The result is a clean river-bed and banks at all times. The Spicket and Shawshine rivers discharge—say, one-hundredth of that of the Merrimac; and no deleterious effect, that I am aware of, is noticed from the small amount of sewage discharged into these streams."

In all of the three cities just mentioned, the discharge of sewage into the river is at points considerably below the source of water-supply. Lowell and Lawrence have large filtering-galleries; the water used in Haverhill comes chiefly

from three ponds in the vicinity of that city. Still, in at least Lowell and Lawrence, the inhabitants are more or less dependent directly upon the river for the water which they drink; and the amount supplied to them for domestic purposes from this source, is likely to increase from year to year, while the relative pollution of the river must increase at a still more rapid rate, unless special provision be made to prevent it. At Haverhill, the lowest point in the river to which we have referred, there is no contamination of the Merrimac appreciable by the unaided senses, except at the mouth of Little River. The water taken just above the city supplies those of the inhabitants who live on high land. It is considered of very good quality.

Newton, Waltham and Brookline have built large reservoirs near the Charles River, from which they get their water-supplies. When such reservoirs were first planned, it was thought that by being placed near rivers they would be supplied by them, and that the intervening walls of sand and gravel would serve as extensive filter-beds to remove any impurities which might exist. It has been found, however, that the water of such reservoirs is probably supplied chiefly by deepsprings or underground streams running toward or parallel to the rivers. This theory is upheld by the following facts:

I. Chemical analysis shows in such cases that the water of the reservoirs contains a very much larger proportion of inorganic matter than that of the adjacent river.

II. The temperature of the water in the reservoirs remains quite constant throughout the year, while that of the river varies from twenty to thirty degrees between summer and winter.

III. Although the water in these reservoirs maintains a level not very different from that of the river, still the two are not so nearly alike as to lead us to suppose that the one is wholly dependent on the other.

It is more than probable, however, that some water passes from the river into such reservoirs,* and, it is therefore pru-

* Dr. F. de Chanmont, conjoint professor of military hygiene at the Army Medical School, Netley, concludes from his experiments and analyses of water in the vicinity of the River Hamble, that, if sewage is poured into a stream, it will, in a porous soil, contaminate the neighboring wells. Much more, of course, would it affect the water of reservoirs quite near the banks.

dent to guard such streams with a considerable care. In this connection, it is appropriate to quote from a recent report by Drs. Swan, Wood and Bowditch.*

“The water-supply should be ‘incontaminable by drainage.’ There is no demonstrable safety in a middle course. No one has conclusively shown that it is safe to trust to dilution, storage, agitation, filtration or periods of time for the complete removal of disease-producing elements, whatever these may be. Chemistry and microscopy cannot and do not claim to prove the absence of these elements in any specimen of drinking-water. They discover pollution; and pollution is somehow intimately associated with the production of certain diseases. Our germ, fermentation and other theories indicate our actual ignorance of the ultimate nature of that cause or those causes whose action we nevertheless rightly infer. These deductions from the observations of cases and their surroundings have been so often repeated that we cannot afford to disregard them. Chemistry in these cases has been invaluable in pointing out the fact and source of contamination; but it has not indicated the quantity and quality of the specific cause.”

With reference to the pollution of the air of cities or towns by the filth discharged above them, Worcester, Peabody, and the cities comprising the metropolitan district of Boston furnish the most conspicuous examples. As to the amount of disease caused in this way, our correspondents naturally speak with some caution. That fresh air and fresh water disinfect beside diluting, cannot be gainsaid; and it is chiefly among dense populations, or where the poison is very concentrated, that we should naturally expect evil results from this source. That filth-infection of the air seriously depresses the vital powers, and that it is one of the chain of causes producing epidemics, are matters of common observation.

REPORTS FROM VARIOUS LOCALITIES.

In many cases the information which has been got from the different cities and towns illustrates general principles so well, that somewhat detailed statements are given from some of the replies of our correspondents. The writer has also person-

* Report of the Medical Commission upon the sanitary qualities of the Sudbury, Mystic, Shawshine and Charles River waters. (City Doc., No. 102, Boston, 1874, pp. 12 and 13.)

ally examined many of the localities referred to, and has added his own notes.

*Boston.**

"I. Boston is supplied with water from four sources, Lake Cochituate, Mystic Pond, Jamaica Pond and the Sudbury River.

* In the Metropolitan District are included Boston and many of the neighboring cities and towns, which, though at present distinct, are so connected in many ways, that they are likely at no very distant day to be joined under one city government. They are, therefore, and for convenience' sake, all represented on the accompanying map. A table of statistics, prepared by E. R. Howe, C. E., is also given, as follows:—

CITY OR TOWN.	AREA.			Miles of Streets.	DWELLINGS.			Population.
	Upland—Acres.	Low and Marshy Land—Acres.	Total, not including Streets—Acres.		Occupied.	Unoccupied.	Total.	
Boston, ...	8,810	10,635	19,445	430	40,817	1,931	42,748	341,919
Brookline, ...	3,500	500	4,000	37	1,065	30	1,095	6,675
Cambridge, ...	2,415	1,045	3,460	75	7,238	531	7,769	47,838
Somerville, ...	2,312	443	2,755	73	3,562	406	3,968	21,868
Everett, ...	1,450	650	2,100	17	700	70	770	3,651
Chelsea, ...	406	620	1,026	45	3,517	314	3,831	20,695
Revere, ...	2,100	1,300	3,400	16	246	36	282	1,603
Winthrop, ...	697	185	882	10	123	22	145	663
Totals, ...	21,690	15,378	37,068	703	57,268	3,340	60,608	444,912

CITY OR TOWN.	WATER.					
	Daily capacity of Water-works—Gallons.	Average Daily Consumption—Gallons.	Houses supplied.	Business places supplied.	Sources of Supply.	Total Length of Sewers.
Boston, ...	64,000,000 ¹	18,500,000	30,036	14,640	{ Cochituate Lake, Sudbury River, Mystic Pond, and Jamaica Pond,	166 ²
Brookline, ...	6,000,000	500,000	200	150	Charles River, wells, etc.,	33
Cambridge, ...	8,000,000	3,000,000	9,695	1,724	Fresh and Spy ponds, . .	404
Somerville, ...	12,000,000 ³	1,500,000	2,796	355	{ Mystic Pond, ... }	146
Everett, ...		250,000	375	45		177
Chelsea, ...		1,250,000	2,985	566		—
Revere, ...	—	—	—	—	Wells, etc., ...	—
Winthrop, ...	—	—	—	—	Wells, etc., ...	—
Totals, ...	90,000,000	25,000,000	46,087	17,480		234

¹ Including Mystic;—that is, the *possible* supply from all sources when the works are completed.

² Discharged into Charles and Mystic rivers, Boston Harbor, and Back Bay.

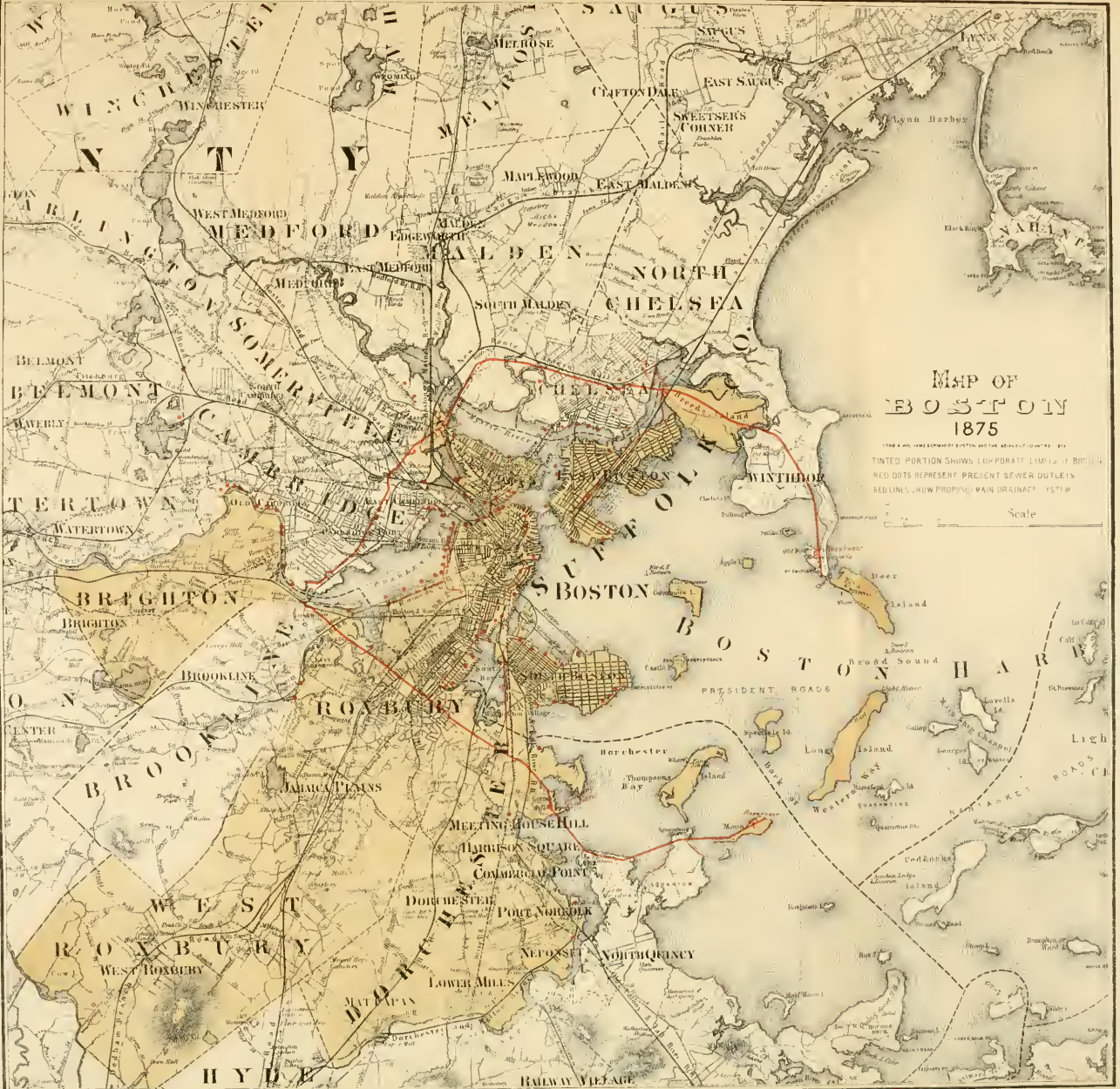
³ Discharged into Muddy Creek and Charles River.

⁴ Discharged into Charles River and Alewife Brook.

⁵ Mystic Pond.

⁶ Discharged into Mystic, Charles, and Miller's rivers.

⁷ Discharged into Chelsea Creek and Mystic River.



MAP OF BOSTON 1875

FROM A ONE MILE BROADMAP BY THE CITY AND LANDS OFFICE, 1874

TINTED PORTION SHOWS CITY PORTAL LIMITS. IF BOSTON

RED DOTS REPRESENT PRESENT SEWER OUTLETS

RED LINES SHOW PROPOSED MAIN DRAINAGE 1875 M

Scale

“*Lake Cochituate* lies in the towns of Natick, Framingham and Wayland. It virtually consists of three lakes or ponds ; in all, three and one-half miles long, three-eighths of a mile wide, and sixty-two feet deep in the deepest part. At high water, its area is eight hundred acres, though ordinarily only six hundred and ninety. Snake Brook enters it near the gate-house, and Farm Pond is connected with the lake at the south-east end by means of Beaver Dam Brook. The waters of Dug Pond (forty-two and one-half acres) and of Dudley Pond (eighty-one acres) are also used as feeders to Lake Cochituate. Pegan Brook, containing some of the drainage of Natick, also flows into the lake at its lower end.

“*Mystic Pond* was formerly at the head of tide-water. The upper pond has been separated from the lower by a dam, and is the source of supply. It is one mile and a quarter long (including the flowage pond at its head), and a half-mile wide. At high water, it is eleven feet deep, has an area of two hundred and thirty acres, and a capacity of forty-five million gallons. The Mystic water-shed, exclusive of the lake itself, has an area of twenty-seven square miles, including the towns of Winchester and Woburn, with portions of Arlington, Lexington, Burlington, Wilmington, Reading and Stoneham. Horn Pond, Richardson’s and Burbank’s ponds, in Woburn, and Wedge Pond, in Winchester, are directly connected with Mystic Pond by means of the Abajonna River, and are the sources of direct supply to the lake.

“The available storage capacity of Mystic Upper Pond is about three hundred and eighty million gallons ; so that, if all the storage facilities above the pond be used, a total daily supply of seventeen million gallons may be obtained in a dry season. The average amount used daily now is about eight million gallons. It is distributed to the cities of Somerville and Chelsea, and to the towns of Everett and Revere, as well as to the Bunker Hill and East Boston districts of Boston. This system is also connected with the Cochituate main, to be used in case of necessity.

“*Jamaica Pond* is situated in West Roxbury, fifty feet above low-tide level, and has a surface area of sixty-seven acres. Its watershed contains about four hundred and forty acres in West Roxbury and Brookline. It has a capacity of supplying one million gallons daily, although it is not all now made available. One hundred families in Brookline, and eleven hundred in wards thirteen, fourteen and fifteen, of Boston, get their water from this pond. The distributing system, introduced in 1840, was by gravitation only ; but, that being now insufficient, a stand-pipe with pump has just been erected, with a capacity of distributing one million gallons daily, and to the tops of the highest houses.

"*Sudbury River* was temporarily connected with Lake Cochituate by an open ditch to Farm Pond, during the drought of 1872. This was again done in 1874. Arrangements have been made for a permanent conduit. The daily supply which may be relied upon from this source will be forty million gallons.

"The following table shows the comparative examinations of the sources of water-supply for Boston. (See pp. 236-239.)

"We have no statistical information by which we can say precisely what the effect of the introduction of water has been upon the health of the community. Cochituate water was first introduced in 1848, and sewers had been then built over thirty years. There is reason to suppose that our returns of deaths in the city are not to be depended upon, previous to 1849; in fact, that they have never been kept with completeness until the Board of Health began a system of accurate registration, last May. The late Dr. George Derby, however, from carefully prepared data, concludes that typhoid fever has diminished.* The water of Cochituate has, probably, not yet been contaminated to a serious degree, but the sewage and drainage of Natick must furnish a cause of some uneasiness to those who drink the water. It has been thought that the filth poured into Mystic Pond affected the health of the people supplied by it, and that, in 1872, the mortality, especially among infants, sensibly increased, owing to the impurity of the water-supply.†

"II. (a.) Owing to the peninsular shape of Boston proper, the sewers follow, to some extent, the natural channels for getting rid of the storm and other waters; and no *system* came into use until after the introduction of water in 1848. Then the lines were short and the grades sharp, and the sewage generally found ready outlets. Large tracts of made land, however, have been added to the original peninsula, increasing its area from 690 to 1,570 acres. The grade of this land has been low, never more than eighteen feet above low-water mark (or eight feet above the level of high tide). Some parts were originally only twelve or thirteen feet above tide at low water. Consequently, the sewers have necessarily been elongated at almost flat grades, and serve to deposit a large part of the sewage instead of carrying it off.

"II. (b.) There are two evils in our sewerage system:

"1st. The sewers do not discharge readily, thereby causing obstructions in house-drains, forcing sewer-gases into the houses, rendering the cellars damp, and incompletely draining the soil.

"2d. They discharge by several dozen outlets, completely skirting

* Second Annual Report of the State Board of Health, p. 126.

† Sixth Annual Report of the State Board of Health, pp. 335 and *seq.*

the city, contaminating the air very widely, and, in some places, rendering it absolutely unfit to breathe. The system, therefore, has been very generally complained of for several years. A special commission has investigated and reported upon the subject. The plans which they recommend are given in the accompanying map.

“II. (c.) As stated above, the sewage is discharged upon large areas of flats or into the docks in the majority of cases, and there can be no doubt of its baneful influence upon the health of the community.

“The sewage of the north part of the city is discharged by a large number of independent sewers, radiating from the high land in the centre. In this part of the city, probably, the injury to health is greater from bad house-arrangements than from the sewers themselves, bad as they, in some cases, are.

“The low made land at the western and southern sides of the city drains partly into the South Bay and partly into Charles River by sewers, which are, most of them, tide-locked and very flat. They are intended to be large enough to serve as reservoirs in case of heavy rain, when the discharge is prevented by a high tide. This prevents the soil from being properly drained; soil-moisture is one of our greatest evils, and consumption causes nearly one-sixth of our total number of deaths each year. Our enormous infant mortality, too, has been attributed partly to this dampness of the soil and partly to the general contamination of the air. In consequence of this failure of the sewers in always discharging their contents speedily, we have many damp, wet and flooded cellars; but many of them, especially at the South End, are below the grade established by the statutes (twelve feet above low-water mark), the law being often disregarded.

“The drainage of Charlestown, East Boston, and South Boston, as will be seen by referring to the map, has many of the faults of the city proper.

“Roxbury is drained partly into the upper end of the South Bay, and partly by the Stony Brook sewer on to the flats beyond Parker Street, a certain proportion of the sewage finally finding its way into the Charles River. With the exception of a small part of Dorchester, which drains into the lower part of the Neponset River, there are few sewers in the outlying wards of the city. In the whole city, including all wards, there are about one hundred and sixty-six miles of sewers.

“III. There are some houses of the poorer class in the thickly settled parts of the city in which no water-closets are used; the liquid part of the house-refuse runs off into the sewers, leaving the solid contents of the privies to be removed by carts.

Examination of the Water-Supplies of Boston.

[Results expressed in Parts per 100,000.]

J A M A I C A P O N D.*

Date.	LOCALITY.	Ammonia.	"Albuminoid Am- monia."	SOLID RESIDUE.			Chlorine.	Remarks.
				Inorganic.	Organic and Volatile.	Total at 212 deg. Fahr.		
Nov. 22, 1875,	Six feet below surface, op- posite ice-houses of Jamaica Pond Ice Com- pany, ...	0.0040	0.0140	4.16	1.64	5.80	0.70	This water has almost as good a quality as that of Lake Co- chituate. The greater amount of chlorine found in it may be largely due to its being so much nearer the sea. There is perhaps, too, some slight indirect drainage from the neighboring population.
	Same point, 12 feet below surface, ...	0.0048	0.0152	3.92	1.56	5.48	0.68	
	Near gate-house, one foot below surface, ...	0.0036	0.0136	4.00	1.64	5.64	0.69	
	Same point, six feet below surface, at bottom, . .	0.0040	0.0128	4.32	1.68	6.00	0.67	
	Mean of filtered, . .	0.0041	0.0139	4.10	1.63	5.73	0.68	

Examination of the Water-Supplies of Boston — Concluded.

MYSTIC POND.*

Date.	LOCALITY.	Ammonia.	"Albuminoid Ammonia."	SOLID RESIDUE.			Chlorine.	Remarks.
				Inorganic.	Organic and Volatile.	Total at 212 deg. Fahr.		
June 13, 1873,	} Bacon's Bridge, . }	0.0133	0.0280	8.00	2.85	10.85	2.12	The contamination of this water-supply by Russell Brook and the Abajonna River, is quite evident.
13, "		0.0136	0.0251	9.00	2.50	11.50	2.00	
13, "		0.0135	0.0216	8.20	1.30	9.50	2.00	
13, "		0.0133	0.0229	8.50	1.50	10.00	1.96	
	Mean of the above four,	0.0134	0.0244	8.42	2.04	10.46	2.02	
June 16, 1873,	Horn Pond outlet, .	0.0076	0.0181	4.90	1.50	6.40	1.24	
16, "	} Russell Brook, . }	1.9120	0.1800	52.50	7.70	60.20	23.60	
16, "		1.7000	0.2000	55.70	5.00	60.70	24.80	
-	} Abajonna River, . }	0.0266	0.0207	8.50	1.70	10.20	1.45	
-		0.0273	0.0241	8.30	1.50	9.80	1.60	

LAKE COCHITUATE.†

July 4, 1873,	Massachusetts Institute of Technology, . . .	0.0033	0.0120	2.84	2.80	5.64	0.34	This water has usually been of exceptional purity.
Sept. 6, "		0.0040	0.0120	2.76	2.06	4.82	0.30	
15, "		0.0033	0.0120	2.40	1.90	4.30	0.31	
Oct. 6, "		0.0033	0.0120	3.24	1.96	5.20	0.34	
25, "		0.0034	0.0080	2.36	2.40	4.76	0.32	
Nov. 15, "		0.0033	0.0132	3.00	2.00	5.00	0.30	
Dec. 19, "		0.0037	0.0100	3.32	1.28	4.60	0.34	

* Analyses by Prof. E. S. Wood.

† Analyses by Prof. W. Ripley Nichols, from Fifth Annual Report of the State Board of Health.

"In the outlying parts of the city, cesspools are generally used. A few of them are also to be found in some of our oldest streets. In some of the new wards, under the demand to have an abundant supply of water, the water-pipes have been introduced without sewers, an evil which will probably be soon remedied.

"IV. The sewage discharged near Prison Point in Charlestown, at Craigie's Bridge in Somerville, on the flats of East Boston, into the basin at the outlet of Stony Brook, at the Roxbury Canal, and on the flats of the Charles River near Beacon Street, has been for years the source of the greatest complaint. It is spread out over many hundred acres of impervious mud, and under a summer's sun is productive of emanations which have often been so vile that workmen have even been obliged to leave their vicinity.

"V. There are very few wells in Boston which are now used. Those few, however, must be looked upon with suspicion, for they are, almost without exception, exposed to danger. The sewage of Boston does not pollute any source of water-supply, except wells.

"VI. Serious discomfort has been frequent. It has been possible, in a certain number of cases, to trace disease, especially diphtheria and a low type of fever, to putrefactive changes in the sewage close to some of the tenement-houses. It is a well recognized fact, too, in our city, among physicians, that disease often assumes a more severe type, and that convalescence is much slower, when patients are exposed to such sewage-polluted atmosphere.

"VII. Stony Brook, above the entrance of the sewer, is jealously guarded by private corporations who use its water for manufacturing purposes; and the slight pollution of a few other small streams cannot do much harm.

"No drinking-water is derived from any source within the limits of the city, except from Jamaica Pond and the neighboring Ward's Pond, which serves as a filtering basin to the former. Both are protected from contamination by direct drainage;* but, on the south shore of Jamaica Pond is a large stable belonging to an ice company, where a large number of horses are kept. Some of their refuse probably finds its way into the pond, although a certain portion would first be filtered through the soil.

"(b.) The atmosphere in the vicinity of the Charles River is polluted seriously, both by emanations from the banks of the river

* Prof. W. R. Nichols appends to his memoranda of analysis of this water, the following: "I did not examine the edges of the pond all the way round, but I think the direct drainage must be small. In samples 1 and 2 we thought we obtained a trifle more nitrogen as nitrates and nitrites than is *naturally* to be expected in water, but the amount was *very* trifling." Prof. Nichols visited Jamaica Pond and took his samples, Nov. 22, 1875.

at low tide and by foul gases arising from the river itself. People are actually sometimes driven out of their own houses by the stench in hot weather, and during the past summer it has been necessary to close windows. The Roxbury Canal is another instance of a similar, but graver, nuisance.

“(c.) Small streams in cities are almost inevitably converted into sewers. There are certain evils, however, which we have seen exemplified in Boston. If such sewers are built tight, the neighboring soil is drained less rapidly than before, in case of heavy rain. If they are built with loosely-jointed stone, as is often done, the sewage passes freely into the soil (as in the case of the Stony Brook sewer) and we have all the evils of loose-walled cesspools, but on a larger scale. If they are built of moderate size, they are gorged in case of heavy rain, the subsoil is saturated, and the cellars are flooded. If they are built large enough to carry off all the flood-water, they serve as immense reservoirs for the collection of sewer-gases during dry weather. If they are kept open, they are filthy, and cause bad odors; but it has not been, in Boston, possible to trace disease directly to this source. In one case, where a stream of small size was first used as an open sewer, it has since been covered in with loose walls, but is too small to carry off the storm-water. Here the cellars are flooded occasionally, and the subsoil becomes saturated with filthy water. I have attributed in one case a certain amount of scarlet fever, typhoid fever and diphtheria largely to this cause, especially as the locality is otherwise wholesome, and the people are clean and intelligent.

“VIII. At the South End, chiefly between Dover and Northampton streets, are between six hundred and seven hundred cellars which are at times wet or damp. In the old parts of the city, where land has been made of bad material, the water soaks through the soil as through a sponge, and the cellars of a large part of the tenement-houses are frequently wet. Many cellars, however, are very low, some being only four and a half feet above low-water mark, and these cannot be expected to remain dry.

“IX. All the sewage emptied into the Charles River above Boston helps to render the river a polluted instead of a pure one. Being at a low level, having a large drainage-area, and flowing through or by quite a number of manufacturing towns, it becomes the natural receptacle of much of the refuse-matter from them. How far down such matter is carried without deposition and chemical change sufficient to prevent it from seriously polluting the atmosphere, it is impossible to say; but there can be no doubt that the evil must become a serious one if measures be not taken to prevent it. A similar statement may be made of the Neponset River. Much of the sewage of

Cambridge and Somerville, including the large pork-packing establishments of the Miller's River Basin, discharges now on the flats of the Charles River. It cannot be said how far its poisonous influence extends over the cities adjacent.

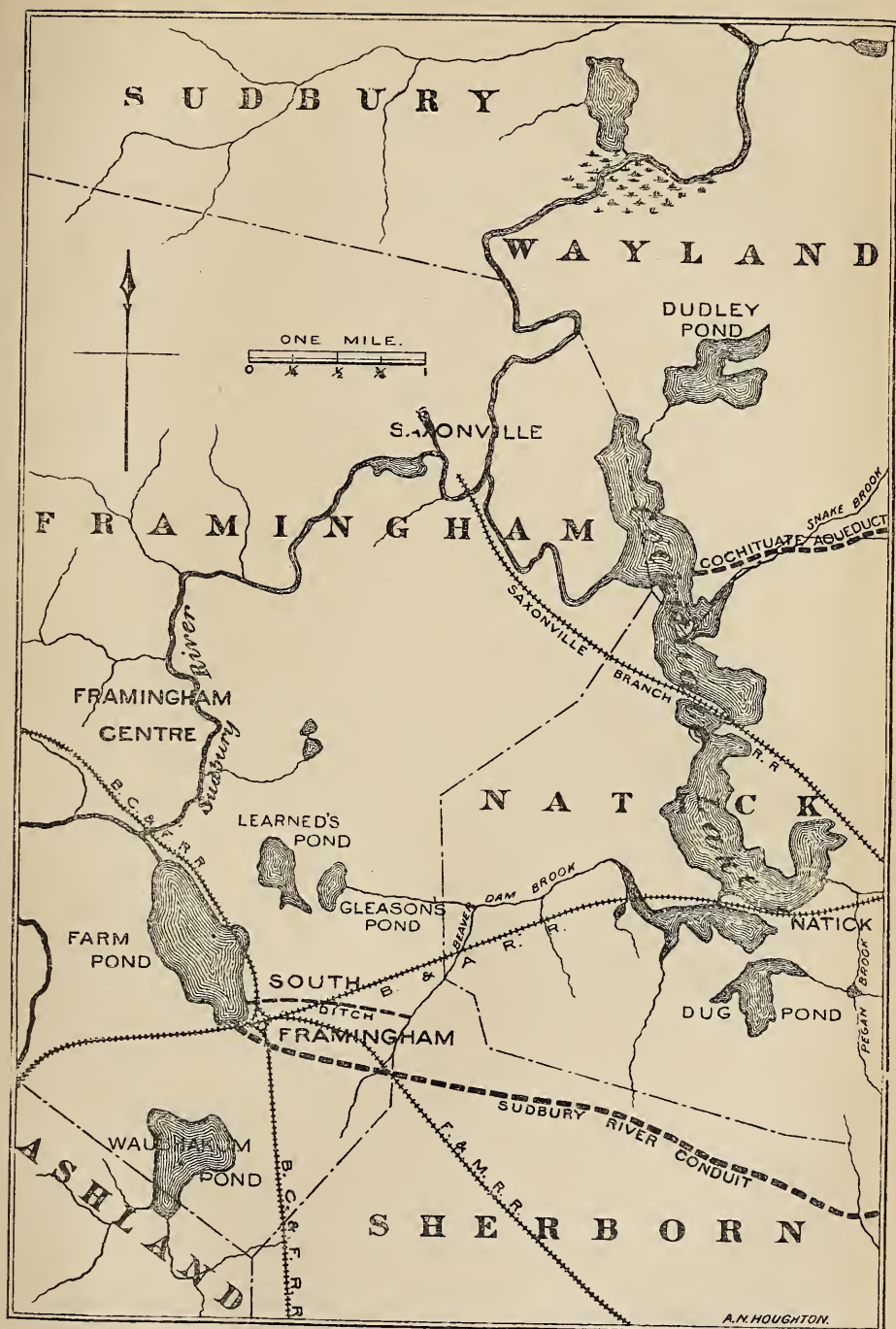
"Cochituate Lake is in danger of contamination from Pegan Brook, a small stream flowing through the town of Natick, and receiving from it the house-sewage and the refuse from several factories. Two plans are proposed for diverting this nuisance: one to drain Pegan Brook into Bacon's Brook, a tributary of Charles River, which it enters just above South Natick; and the other to divert the sewage into the Sudbury River near its junction with the Concord, by a sewer passing around the west side of the lake. By either plan, it would be necessary to cut off from the lake about a square mile of its drainage-area.

"The country drained by the Sudbury River is but thinly settled, nor is it likely to be built up rapidly; it contains few soluble rocks or earths, has quick slopes, and there are very few manufactories along the banks of the river; so that the water is quite pure. After heavy rains in the summer and autumn, when the drainage-surfaces are covered with decaying and dead vegetable matter, the water becomes somewhat discolored, and has a slightly bitter taste. It is then unfit for bleaching purposes. The color and taste, however, disappear on storage. The towns of Framingham, Marlborough, Westborough, Ashland, Southborough and Hopkinton, are on or near the Sudbury and its tributaries, and probably drain more or less into these streams. The quality of the water must in time become affected, unless these towns are provided with some proper system of sewerage to carry away all sources of pollution from the water-courses. It is proposed to have several storage-reservoirs for the supply from the Sudbury River.

"Farm Pond is in danger of pollution from its proximity to the growing town of South Framingham.

"The natural waters of the Mystic Valley are very pure and colorless, but the tributaries of the lake have for a long time been used as receptacles for the refuse from a large number of tanneries, wool-scouring establishments, etc., in Woburn and Winchester. These towns have not yet sewerage-systems, but drain into cesspools, ditches, etc. On the tributaries of Mystic Pond are fifty-five factories, of which twenty are leather-works, and they employ about three thousand men. It is estimated that about seven per cent. of the water that flows into the upper Mystic Pond is the drainage from factories.* Fish have been killed in the pond, and cattle have refused to drink the water of the Abajonna River.

* Report of the Cochituate Water-Board, 1874, p. 20.



A.M. HOUGHTON.

COCHITUATE LAKE,
and other Sources of Water Supply of Boston, 1875.

“The legislature has given to the city of Boston permission to discharge all this offensive sewage by an intercepting sewer into the lower Mystic Pond, where the tide rises and falls only a few inches. This would make a cesspool on a colossal scale; for experiments made by the State Board of Health during the past summer show that sewage would remain indefinitely in the pond without any discharge.

“A later plan is to discharge the sewage into the Mystic River, as shown on the accompanying map,* at a point two thousand feet below the pond; but this is likely to be the source of nuisance, if carried out, and at no very distant time.

“X. There is no feasible remedy excepting a long intercepting sewer to discharge at some distant point by means of pumping.”

Additional facts are given of the condition of one of the tributaries of Mystic Pond in the following notes of an inspection of a portion of the East Branch of the Abajonna River for a distance of two hundred and fifty rods in a straight line, or about a mile and a half by the course of the brook.

Alongside Washington Street where the brook flows, all weeds, etc., in its bed were coated with an ash-colored substance, of slimy feel, which completely concealed the green of the plants. On close inspection this seemed largely composed of minute shreds. The planks in the apron of an old dam twenty-five or thirty rods above showed the same coating. This same appearance was found all the way up to the glue factory (also in the canal which diverts a portion of the water). No fish or aquatic insects were seen between the two points mentioned. The water is at first slightly turbid, and grows more so till the factory is reached. It becomes of the color and opacity of very foul sink-wash, within a quarter of a mile of the factory.

The works stand on rising ground some five hundred feet east of the stream, and quite near the Stoneham Branch Railroad. West and south-west, and between them and the stream, are five or six acres of boggy meadow, on which there was everywhere standing the disgusting yellowish-white drainage of the works, several inches deep. From a distance of two hundred and fifty feet could be seen the whitish stain of two streams of drainage running down from the factory

* See page 244.

into the meadow. In the north quarter of this meadow were a number of settling-grounds for the drainage, bordered by old boards, with a little rampart of earth about six inches high thrown up against them, within which a space perhaps sixty feet square was flooded with sewage. From arranged outlets, streams of this stuff run directly into the brook. Only one of these areas was in use, several others being bare, not dry. One rod above the grounds of these works the brook was clear, and the aquatic vegetation bright and healthy. A little farther up I saw aquatic insects in numbers.

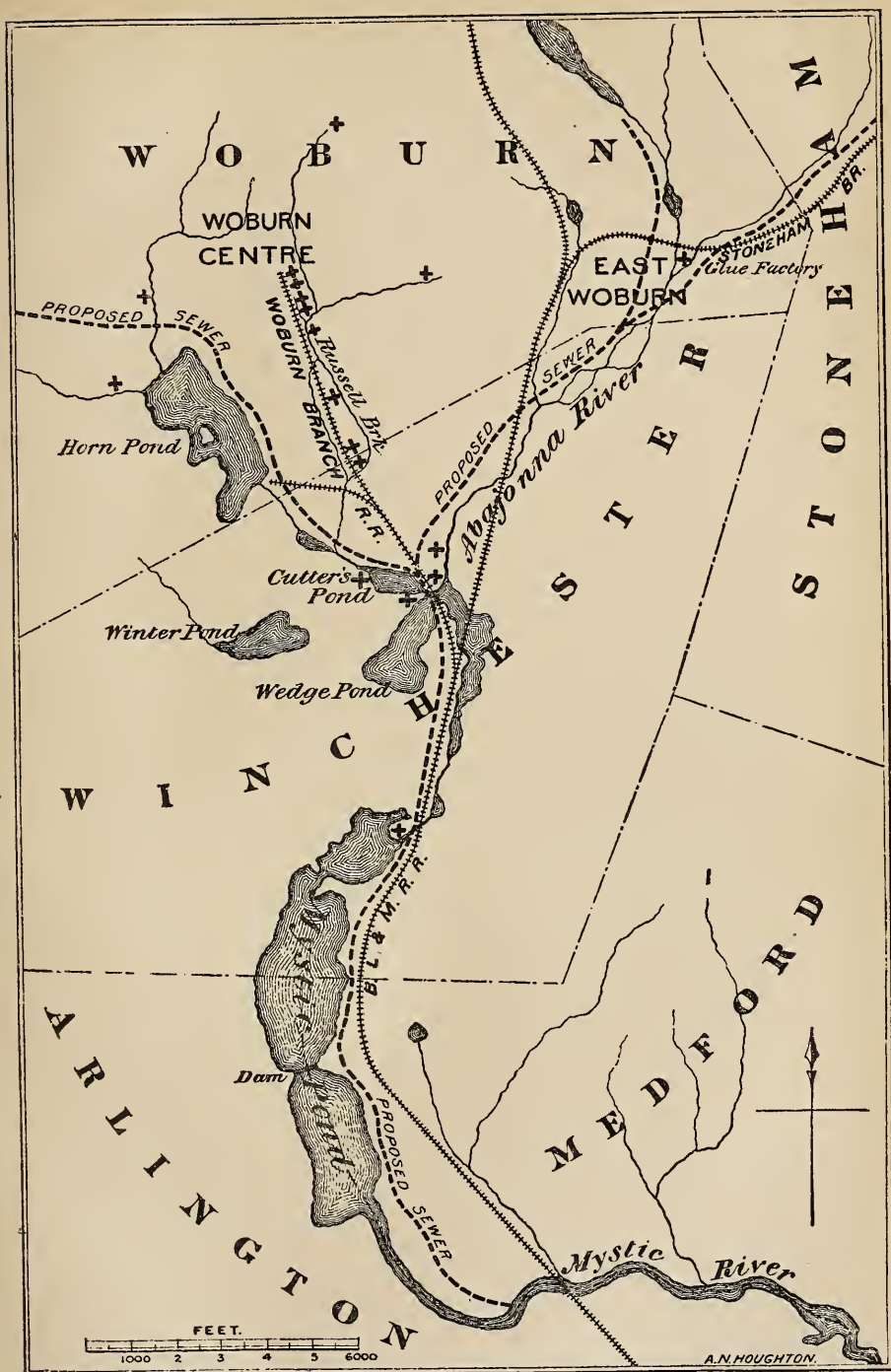
In some parts of the stream fish are sometimes killed in great quantities. Such was the case early last September, on the twelfth day of which month the little mill-pond (where the canal approaches the main brook) was full of dead fish, some floating, some sunken. Eels two feet long, and fry an inch long, alike found the water too strong for them.

The industry which thus poisons this valuable stream, is the washing of hair scraped from hides in the process of currying, and loaded with putrescent animal matter and lime; also the manufacture of glue from the refuse of currying-shops and slaughter-houses. It is a profitable and growing business. One-sixth of a mile lower, the stream is entered by the drain from a large tanning and currying shop in Stoneham Centre, into which also enters much other sewage from factories and dwellings in the same town.

Statistics of Leather Manufactories of Woburn and Winchester for 1875.

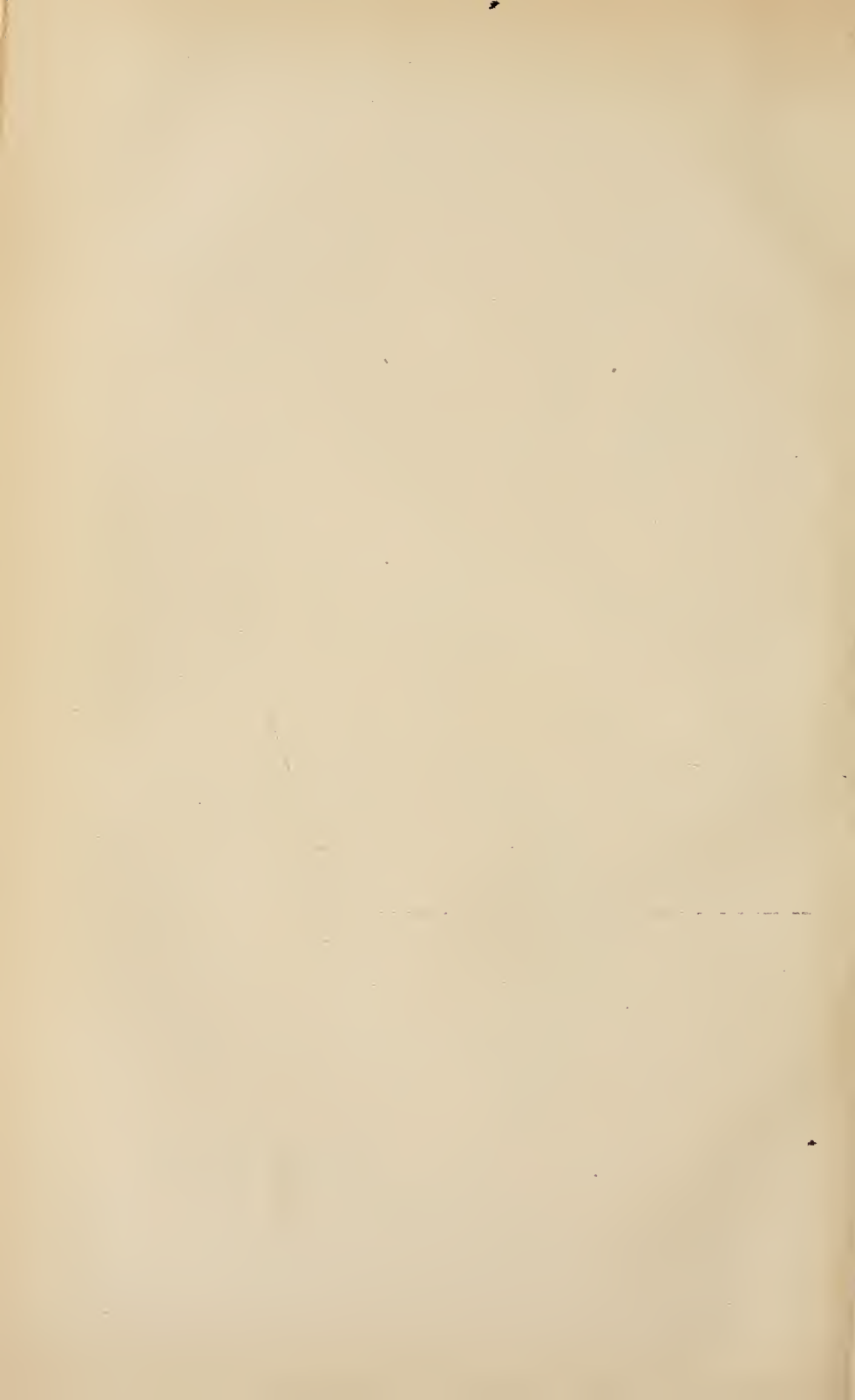
Business having been duller than in 1874, the figures will be found lower than those for that year given in the "Report of the Mystic Water-Board in relation to Sewage," or those for the same year given in the report of the medical commission on the sanitary qualities of the Mystic and certain other waters.

Number of hides finished per week, ...	5,200
of hides finished during year, ...	270,400
of barrels of lime used during year, ...	108,160
of pounds of soda used during year, ...	42,204
of pounds of sulphur used during year, ...	42,204
of gallons of water used during year, ...	108,160,000



HEAD WATERS OF MYSTIC POND.

+ Denote Sources of Pollution, mostly Leather Works.



To each hundred hides there are used 40 barrels of lime, 16 pounds of soda, 16 pounds of sulphur, and 40,000 gallons of water. The most of this filth drains directly or indirectly into the waters of the Mystic basin.

Specimens for chemical analysis were taken from Lower Mystic Pond, in consideration of a proposition to empty the sewage of Woburn and Winchester into it. It was known that there was very little current out of this pond, and that the tide which enters twice a day from Mystic River, so far from scouring it, tends only to bring in more filth. Moreover, the shape of the bed of this pond forbids its ever changing its water fast enough to prevent decomposition of filth that once enters. The bar crossing it, and separating it from the upper pond, is sufficiently broken down to allow of some wash over from one to the other; for when the depth of water on this bar is compared with that of the basins, the interchange between them hardly deserves any other name. In November, 1875, some floats were placed in the northern part of this pond, and their movements watched during fourteen days. For the most part they swung about the spot where they were placed, without crossing the bar or approaching either shore. On four occasions, when the wind was fresh, they reached the shore, twice to the eastward, once to the westward of the spot where they were set adrift and above the bar; once only far to the south-eastward of the bar. Not one of them reached the outlet.

The specimens referred to were taken at different depths, varying from twelve to forty feet, by an apparatus which prevented the entrance of any water until the desired depth was reached.

Comparisons of analyses made, from fifteen years ago to the present time, by chemists as well known as Silliman, Horsford, Hayes, Merriek and Nichols, show the water of this Lower Mystic Pond to have been very foul during the whole of that period, and to have been growing gradually worse, although there are very few dwellings on the large estates which border them. The introduction of the vile

sewage of the tanneries, etc., elsewhere described, could result only in making an enormous cesspool of this pond.*

Prof. Nichols remarks with regard to the analyses given in the following table :—

“Nos. 1 and 2 contained enough sulphuretted hydrogen, when opened, to color lead-paper held over the mouths of the jars. On boiling the water the sulphuretted hydrogen was driven off and estimated. On subsequent treatment with acid, only a trace of sulphuretted hydrogen was obtained.

“There is no significance in determining the ‘loss on ignition,’ as the mineral matter is decomposed to such an extent in such waters.”

Examination of Water from Mystic Lower Pond.†

[Results expressed in Parts per 100,000.]

Number.	Date.	LOCALITY.	Ammonia.	“Albuminoid Ammonia.”	Total Solid Residue at 212 deg. Fahr.	Oxygen required to oxidize organic matter.	Sulphuretted hydrogen.
1,	1875,	{ Mystic Lower Pond, }	0.3040	0.0480	1,102	2.570	0.46
2,			0.5040	0.0688	1,465	3.197	1.86
3,			0.6400	0.0672	1,733	5.736	0.07

† The waters of the pond are shown by this analysis to be already so filthy, that any addition of sewage could be looked upon only as a very grave evil.

Chicopee.

“Water has been introduced by an aqueduct company from springs which appear through the sand on the high plateau above the Connecticut River. This water is almost universally used in the village, and is pure at the start, where it comes up through sand. By the use of logs, lead-pipe, etc., as conduits, and from the foulness of reservoirs, the water, when drawn at the houses, is often rendered impure, especially when it is so low as to be kept shut off from nine o’clock, A. M., till five the next morning, as is the case often in summer. A small stream reaches the faucets in the cellars, sometimes when none can be had above-stairs. The inadequate supply of water is getting to be a great evil here. The aqueduct company

* The plan has now been abandoned in favor of one to discharge the sewage at a point in Mystic River, where it can hardly fail to be a source of nuisance in time.

have kept continually adding to their list more families to be supplied with water, as the village became more built up,—while there has been no considerable addition to the source of supply. The effect, of course, has been to cut nearly everybody short of the necessary quantity of pure or freshly-drawn water, in summer, when cool water is most needed, for a part of the twenty-four hours. A disease has been prevalent here, which the people call the ‘water diarrhœa,’ believed to be caused by the low-water impurities.

“This condition of the water must have a more or less injurious effect on the health of the people. In many places we cannot drive wells. Where they can be dug, the water from them is often ‘swampy,’ and bad tasting.

“The town has, at considerable expense, prepared a general system of sewerage for the village, but the plan is as yet only partially carried out. It is satisfactory so far as it goes. We have a few large sewers, and some smaller ones, but the one or two most needed—those which would drain the most crowded streets of the town—are not yet built.

“Where the sewers are not built, the sewage from most of the corporation buildings runs into the canal, which feeds the factories with water-power, and thence into the Chicopee River. Almost all of the sewage from the village where sewers are not built (probably more than one-third of it) runs on to the surface. Perhaps one-fourth goes into sink-holes. We have but few cesspools. That which runs on the surface is often offensive. Very many wells are exposed to contamination from privy-vaults, and are seldom used.

“We have formerly had typhoid fever in Depot Street from surface-sewage, I have not a doubt; also in West Street, from the open mouth of a large sewer; also cerebro-spinal meningitis, two years ago, from a pool of foul sewage which collected in Park and Spruce streets. This was finally drained off into a small brook or water-course, open for thirty or forty rods. This brook is now, however, being made into a covered sewer. There is no serious offence here after the sewage has once reached the water-courses.

“I have been satisfied for years that damp and wet cellars have caused fever and other forms of disease. We have more typhoid fever on Front Street than anywhere else among the same number of people. The street faces the canal, and is heavily shaded with elms. Many of the cellars are damp.”

Fall River.

“A considerable portion of this city in the low-lying districts suffers from a damp soil, wet cellars, and consequently, from a considerable measure of disease, owing to the fact that a mill-dam has

raised very decidedly the level of the adjoining water, thus obstructing the natural drainage of the soil. A competent engineer, however, has examined the question thoroughly, and advises that the dam be removed. The matter, therefore, does not require further comment at present."

Haverhill.

"*Little River* is a large brook, rather than a river, flowing through the western part of the more thickly-settled portion of Haverhill. It is the natural outlet for the surface-drainage of this part, below the level of which its valley, in width about three hundred feet, sinks about twenty feet (as is shown in the diagram of a cross-section of this valley). Its length in a straight line from Hale's Pond to the Merrimac River at Washington Square, as is shown by the second map, is about one-third of a mile. The tide flows somewhat less than half-way up it. At high tide, it is about thirty feet wide and three feet deep. Sometimes it is scarcely a foot deep in mid-channel. Its left bank, between the upper bridge and Washington Square, is very low and flat for about one hundred feet from the stream, and showed in two places at least an extra channel (dry). This shore was slimy, overgrown with tall, rank weeds, and is evidently a regular garbage-ground for the reception of 'dry dirt' and offal, which were soaked in sewage. Here and there lay dead cats and fowls. It then rises sharply (say at an angle of forty degrees) to a level of some twenty-five feet higher. This broken bank is crowned with the privies, hen-houses, pigpens, etc., of the poorest class of dwellings. Three public sewers and many private drains open on it. The right bank has much less low ground, and the dwellings along it are of a somewhat better order. For two hundred and fifty or three hundred feet here the stream is bordered by a wall nine feet high, made of large stones, without mortar; three or more privies overhang it; three public drains, and all the house-drains, empty on this bank. Above the bridge the population is more sparse, and there is the same state of things in a less concentrated form. At the gas-works, near the dam (see map), the stream makes a pool, and just above is again rapid. At the dam is a woolen mill. In times of drought, when this mill is idle,—as on Sunday,—the bed of the stream is *dry* down to 'tide-water.' At Washington Square the current is sluggish. This 'square' is the very centre of the business part of Haverhill, four principal streets converging there (see diagram), and is about twelve hundred feet from the station of the Boston & Maine Railroad. It bridges *Little River*, the distance from the water to the key-stone of the arch being twenty feet. Below Washington Square the stream and its banks are an offence to sight and smell.



Cross section at head of tide water of Little River.

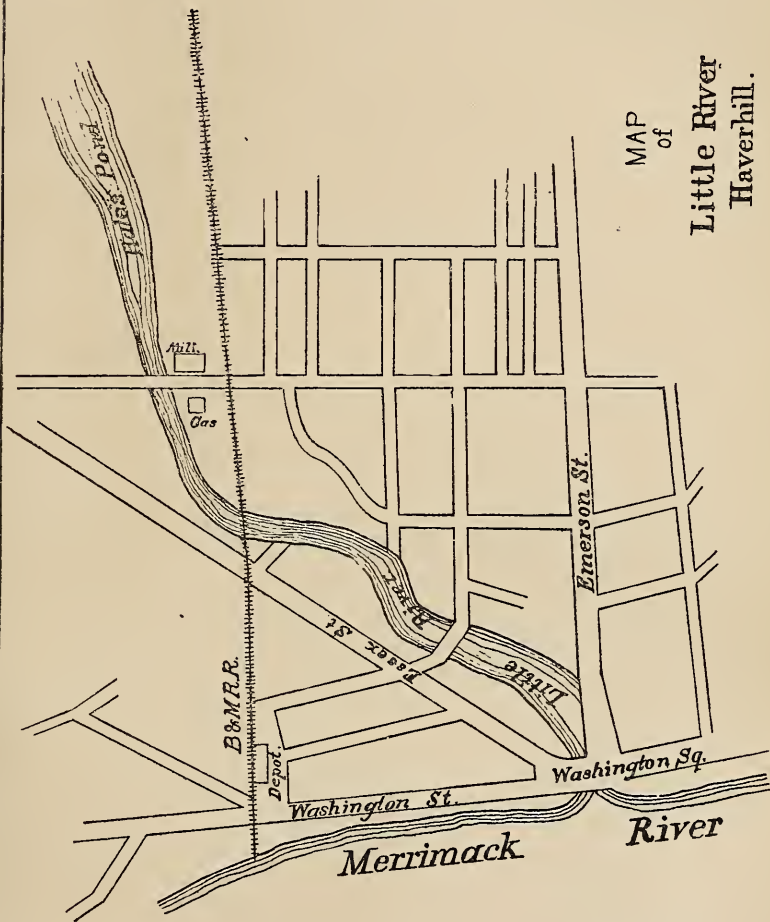
*A & B. Channels of River 30 feet wide and 3 feet deep
at high tide.*

C Flat Eastern shore 100 feet wide

D East bank 20 feet high

E West bank "

MAP
of
Little River
Haverhill.



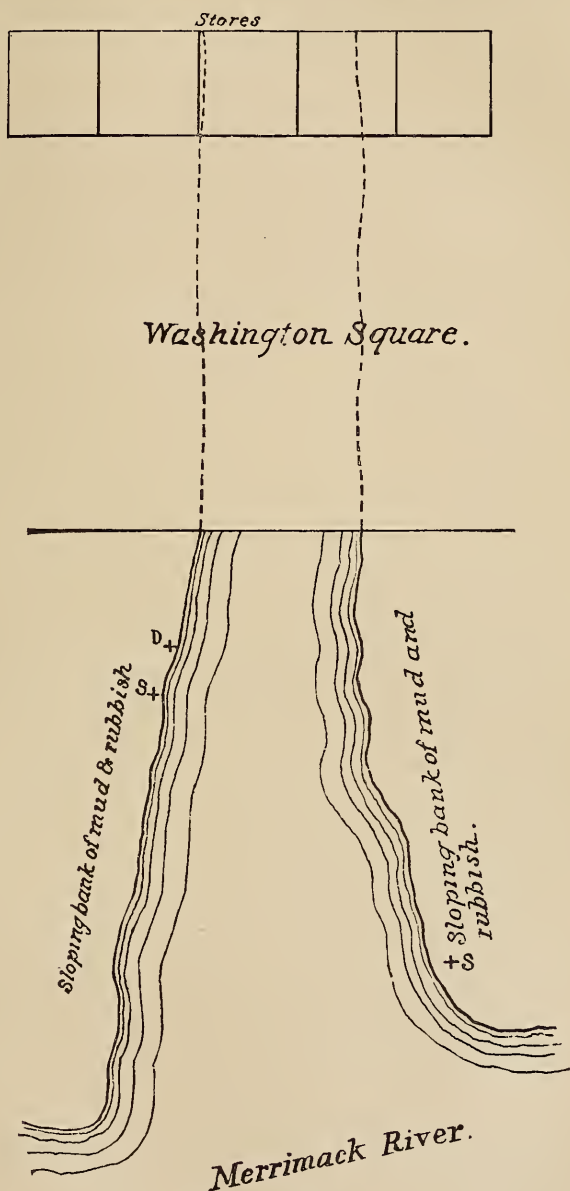


Diagram of mouth of Little River

Dotted lines show the Stream bridged over by Washington Sq. and stores, about 140 feet. Banks 125 & 150 ft. respectively from Square to Merrimack River. SS, small sewer. D, large drain.

For particulars, see diagram. Extended comment is unnecessary. The whole valley of this brook is foul and unwholesome. On inquiry from physicians, I was told that sickness is frequent and severe in the dwellings bordering it."

Further particulars in regard to Haverhill are given in the following extracts from the reply to our circular :—

"We have sewers, but can hardly say that we have any sewerage-system. Sewers have been constructed from time to time, although without much reference to a system, and most of our principal streets now have them, discharging their contents into the Merrimac and Little rivers. Many of the sewers enter the river through a line of wharves above the high-water mark. The odor arising from this source is often offensive, but no marked effect upon the health of the community has been noticed.

"Little River, a small stream entering the Merrimac at Washington Square, receives the filth from the gas-works, and also from several large manufactories. It also receives the sewage coming from the western slope of the city. When the stream is swollen by freshets, this sewage is easily carried into the Merrimac; but in summer, when the water is low, the filthy mass is spread over the river-bed, and the odors arising therefrom are extremely offensive. Much of it is deposited on the flat surface at the mouth of the river, and at low water it presents a most disgusting sight to the multitude of people constantly crossing the bridge. The odor frequently arising from this reeking filth is very offensive. We hope soon to succeed in remedying this evil by extending the arch of the bridge to the line of the Merrimac. This is a striking instance of the bad effects arising from the use of small streams for sewers. The water of Little River is not used for drinking purposes.

"Our city is located upon a heavy clay deposit, and nearly all our cellars are more or less damp. This evil is largely obviated by sewers and cemented cellars. In the newer portions of the city the evil is more apparent, and sickness can often be traced to this cause."

Lynn.

"There is a stratum of dense clay, impervious, of course, to water, underlying the whole of the city of Lynn, with the exception of the rocky hills which are situated in the rear, and which are only to a limited extent inhabited.

"The depth of this stratum beneath the surface varies. In some places it rises to the surface, or near it; in others, dips down, forming valleys and basins of varying shape and extent. It is, in reality,

an irregularly undulating stratum. The basins act as reservoirs for the storage of water, sometimes being far underground, sometimes coming near the surfaces and forming marshes or bogs, and sometimes showing themselves as open ponds. The valleys are the channels for the discharge of overflow, giving us either open or subterranean water-courses, or brooks.

"The stratum of clay is variously covered with fine sand, fine and coarse gravel, mixed with bowlders and loam. The hills in the rear have a basis of solid rock, chiefly porphyry, which crops out in many places, but is for the most part covered with loose gravel and loam.

"At Harbor Street, and in the vicinity, the clay comes up to the surface, or to the loam. There is a brick-yard there. From this point easterly, across Pleasant, Market and Washington streets, to the rising ground, the clay is nowhere more than four feet below the surface. From Washington and Munroe streets north-westerly to the junction of Essex and Washington streets, the depth averages about four feet. The region thus indicated constitutes a sort of valley through which a brook once ran, which was cut off, or diverted, by the Market Street sewer.

"Beyond Essex Street, in the region of Hanover, Johnson, Leighton streets, etc., the clay is deeper—eight to twelve feet below the surface. Here was a basin, formerly a swamp, drained by the aforementioned brook, but now drained more perfectly by the sewers, and built up with residences. Young people, less than thirty years of age, have told me that, when children, they used to go to this place to skate, as in winter it was often a pond; now there are very few vacant lots there.

"At the corner of Summer and Market streets the clay is not more than four feet below the surface. A few rods west it falls down suddenly to nine or ten feet.

"In the region of Silsbee, Green, Nahant, Ocean and Lewis streets, and towards Wood End from this section, the clay is much deeper. In the valley of Stacey's Brook (east side) and its branches, it is somewhere about eight or ten feet deep. At Bog Meadow (the swamp back of the soap factories) it is deeper, giving us another basin. The meadow is drained by Stacey's Brook. At Glenmere, around said meadow, it is also quite deep, and beyond, dips down probably under Flax Pond and its tributaries. On Holyoke Street (west side) there are three brick-yards, showing that the clay is at the surface. This is in the region of Stony Brook and branches. (I think there is a branch from the direction of Holyoke Street.) At Cottage Street there is another brick-yard. The stratum runs down as you go from this point towards the common (south-east),

and in some places reaches a depth of thirty feet below the surface. In some sections of the city there have been found double layers of clay, as at the corners of Broad and Farrar streets, Whiting and North Common streets, etc. There are found gravel and sand between.

"On Boston Street, not far from Cottage, a well was sunk through the first stratum of clay. The water rose much higher than the stratum from whence it came, and now flows out constantly, showing, of course, two impervious strata dipping down at that point.

"In the region of Silsbee, Green and Chestnut streets, etc., there is an underground pond. The rim of this clay basin was cut by the Union Street sewer, and many wells either lowered or drained entirely. There is fine sand in this basin, as in that one spoken of at West Lynn.

"Water was introduced from Breed's Pond in 1870 and 1871; from Beaver Pond in 1873. The water cannot be said to have been fairly introduced until the beginning of 1872. It is now pretty generally supplied to the thickly-settled portions of the city, and is of fair quality, although that from Beaver Pond is discolored by vegetable matter, and has a 'swampy' taste. It is perhaps too soon after the introduction of the water to determine its effect upon the health of the community. A study of the mortality reports, however, gives us the following facts:—

Average number of deaths per year from 1869 to 1871, inclusive,	562.3+
" " " " " 1872 to 1874, ' "	721.3+
Average number of deaths from typhoid fever from 1869 to 1871, inclusive, ...	28.6+
Average number of deaths from typhoid fever from 1872 to 1874, inclusive, ...	22.6+
Ratio of deaths from typhoid fever to the whole number of deaths from 1869 to 1871, inclusive, ...	5.09+
Ratio of deaths from typhoid fever to the whole number of deaths from 1872 to 1874, inclusive, ...	3.23+

"Thus, I have compared the three years that have elapsed since the introduction of water with the three years immediately preceding, and have shown that while the mortality from all causes combined has been greater for the first-named period, that from typhoid fever has been both relatively and absolutely less. It is but fair to take into the account the fact that the population of the city has been, on the average, greater by some thousands during the three years since the introduction of water than for the previous period. This partially explains the increase in the whole number of deaths, and emphasizes the diminution of typhoid.

“During the past winter and spring, the supply of water was, for a portion of the time, short, and of very poor quality. Great numbers of the service-pipes, also, were frozen. Owing to these circumstances, people resorted, in many instances, to their old sources of supply,—the wells, which were also low. There was an unusual amount of typhoid fever in the city during this period. A large number of cases, and eight deaths, occurred from January to June, a portion of the year in which, ordinarily, the disease is but rarely observed.

“The harbor-bottom is composed of mud, and is almost entirely bare at low water. The tidal-flow reaches the mouths of the sewers, except in one instance, that of the Shepherd Street sewer, which discharges on the flats. The sewage is not properly carried off into deep water. Its solid portions accumulate near the mouths of the sewers, and are very offensive. When the wind is from that quarter, the odor of the sewage-mud is plainly perceptible at a distance, in the higher portions of the city. The region which borders the harbor and flats is the most unhealthy part of the city, a fact due partly, perhaps, to the sewage, and partly to other causes. As the sewers have all been constructed within a few years, the evil from this improper disposal of the sewage is one only just beginning to be felt. It must constantly increase, and, unless remedied, become a great source of discomfort and disease.

“As the number of sewers is so small, and only 360 private drains in all connect with them, the greater part of the sewage of the city must be disposed of in some other way. It is, perhaps, fair to state that one-third part of this amount runs directly on to the surface, or into uncovered sink-holes, or under privies without vaults; and that the remainder runs into cesspools, including, under this term, the casks or hogsheads set into the ground, and the old-fashioned vaults. The proportion which runs under privies, or into vaults under privies in the house, or dwellings connected with the house, is very small. Of that which runs into cesspools, about three-fourths, I should judge, runs into casks set into the ground, and covered up; the remainder into regularly constructed cesspools.

“In many instances, these receptacles of sewage are very near the dwelling, and wells are directly contaminated from them. They also sometimes leak into cellars, and their emanations contaminate the air of the house. The foul water is allowed, for the most part, to soak away into the ground. In this way, the whole soil about the dwellings has become filthy, so that there is no security for the purity of well-water within the thickly-settled portion of the city.

“About one-fourth part of the ground-drainage of the whole city,

including the sewage of families and of manufactories, the washings of streets, and of the soil about dwellings, goes directly into ponds and brooks. It is, of course, understood that this amount includes a portion of that which was said to have been discharged on the surface.

“There was formerly, for many years, a large dye factory at the upper end of Flax Pond, which received its water, for power and other purposes, from Sluice Pond, and discharged its abundant sewage into Flax Pond. There are now, although the factory is no longer in existence, large quantities of offensive matter deposited from this sewage, at the upper border of Flax Pond. One wool-pulling mill and one morocco factory drain into the pond at the upper end. One glue factory drains into Stony Brook. Two morocco factories drain into the lower part of Strawberry Brook. A large number of morocco factories drain directly into the docks. All the drainage of Wyoma Village, and a part of Glenmere,—with a population of some 1,500 or more,—drain into Flax Pond and its tributaries. Stony, Stacey’s, and Strawberry brooks receive the surface-drainage, and a portion of the sewage of dwellings, from their respective water-sheds. In the rear of Essex Street, between Fayette and Chatham, on the north side, there is a large hollow, and in it a pond, with no outlet, called ‘Silver Lake,’ a decided misnomer. It has steep banks, and on one side of it is a dense and filthy Irish settlement, which, having no cesspools or vaults to its privies, or sewerage, drains everything directly into the pond, which has become, by this means, a reeking mass of foulness. The neighborhood is very unhealthy, abounding in dysentery, typhoid fever, consumption, etc.

“This pond is a short distance in the rear of the Ingalls School, which has a daily average attendance of over 400 pupils.

“There is a probability that Flax Pond and its tributaries may be taken by the city as an additional source of water-supply, but I know of no instance here where the water from pond or brook, contaminated by sewage, is now used for drinking or cooking. Many polluted wells are still used in preference to the water supplied by the city.”

The following table shows the results of the examination of the waters referred to by the medical correspondent in Lynn :—

Examination of Water from Lynn.

[Results expressed in Parts per 100,000.]

Number.	DATE.	LOCALITY.	Ammonia.	"Albuminoid" Ammonia."	SOLID RESIDUE.			Chlorine.
					Inorganic.	Organic and Volatile.	Total at 212 deg. Fahr.	
1	Oct. 21, 1875,	Well, Whiting Street, ...	0.2267	0.0213	33.30	8.00	41.30	4.44*
3	" 21, 1875,	Well, Western Avenue, ...	0.0173	0.0093	26.80	7.90	34.70	5.28†
4	" 21, 1875,	Well, Friend Street, ...	0.0096	0.0051	20.60	3.40	24.00	2.84†
2	" 21, 1875,	Strawberry Brook, ^a	0.0061	0.0133	3.00	1.48	4.48	0.64†
5	" 21, 1875,	Flax Pond, near outlet, ...	0.0160	0.0136	3.12	1.08	4.20	0.56†
	Dec. -, 1874,	Flax Pond, gate-house, ^b	0.0047	0.0122	2.76	0.74	3.50	0.42
	" -, 1874,	Flax Pond, near entrance of Sluice Pond, ^b	0.0053	0.0109	2.00	1.00	3.00	0.42
	" -, 1874,	Sluice Pond, ^b	0.0052	0.0117	2.12	1.04	3.16	0.44
6	Oct. 21, 1875,	Silver Lake, ²	0.0147	0.0790	6.36	6.36	12.72	1.60†
7	Nov. 11, 1875,	Stream joining Sluice and Flax ponds, ^c { Unfiltered, . Filtered, .	0.0012	0.0240	8.32	3.60	11.92	2.36*
	" 20, 1875,	Twenty rods below morocco factory, ⁴ { Unfiltered, . Filtered, .	0.0130	0.0160	4.56	2.24	6.80	-
	" 11, 1875,	} Same stream as No. 7, but near Flax Pond, ⁵	0.0130	0.0140	-	-	-	-
8	" 20, 1875,		0.0087	0.0160	2.20	2.40	4.60	0.72†
			0.0116	0.0220	4.92	3.72	8.64	-

9	Nov. 11, 1875,	Flax Pond, ^d	.	.	.	.	.	.	.	.	0.0061	0.0173	2.60	1.40	4.00	0.68†
10	" 11, 1875,	Strawberry Brook, below bridge, ^e	.	.	.	.	.	.	.	.	0.0800	0.1000	9.12	4.60	13.72	2.00†
			.	.	.	.	.	.	.	.	0.0800	0.0560	—	—	—	—
11	" 16, 1875,	Birch Pond, ⁷	.	.	.	.	.	.	.	.	0.0400	0.0460	3.40	5.00	8.40	0.50†
12	" 16, 1875,	Birch Pond, gate-house, ⁸	.	.	.	.	.	.	.	.	0.0440	0.0512	3.68	4.24	7.92	0.46†
13	" 17, 1875,	Stacey's Brook, ⁹	.	.	.	.	.	.	.	.	0.0188	0.0260	5.40	3.44	8.84	1.20†
14	" 17, 1875,	Stacey's Brook, ¹⁰	.	.	.	.	.	.	.	.	0.0440	0.0280	7.20	3.52	10.72	1.65†

^a Strawberry Brook is the outlet of Flax Pond.

^c Taken some five hundred feet below the goat-skin factory.

¹ Taken below Park Street bridge.

³ Quite black, owing to suspended matter which settles, leaving the water nearly colorless.

⁴ Only slightly colored. No black sediment.

⁷ Deep yellowish-brown color. Taken near upper end, near farm-houses.

⁹ Somewhat colored. Taken above bridge on Brookline Street.

* Nitrates enough to answer to sulphate-of-iron test in unconcentrated water.

† Trace of nitrates when the water is considerably concentrated.

^b Analyses made for the city of Chelsea.

^d Taken about half-way from inlet to gate-house.

² Full of green vegetable matter and low animal life.

⁵ Somewhat colored.

⁶ Quite strongly colored.

⁸ Deep yellowish-brown color.

¹⁰ Somewhat colored. Taken as the brook issues from Bog Meadow.

No. 1 is from a well which has not been used since the occurrence of typhoid fever, attributed to drinking the water from it during the last spring. It is evidently contaminated by drainage.

No. 3 is from a well situated at the bottom of a valley, with a dwelling on one side and out-houses on the other. Five cases of typhoid fever have recently occurred in the dwelling. The water is evidently unfit for use.

No. 4 is from a suspected well.

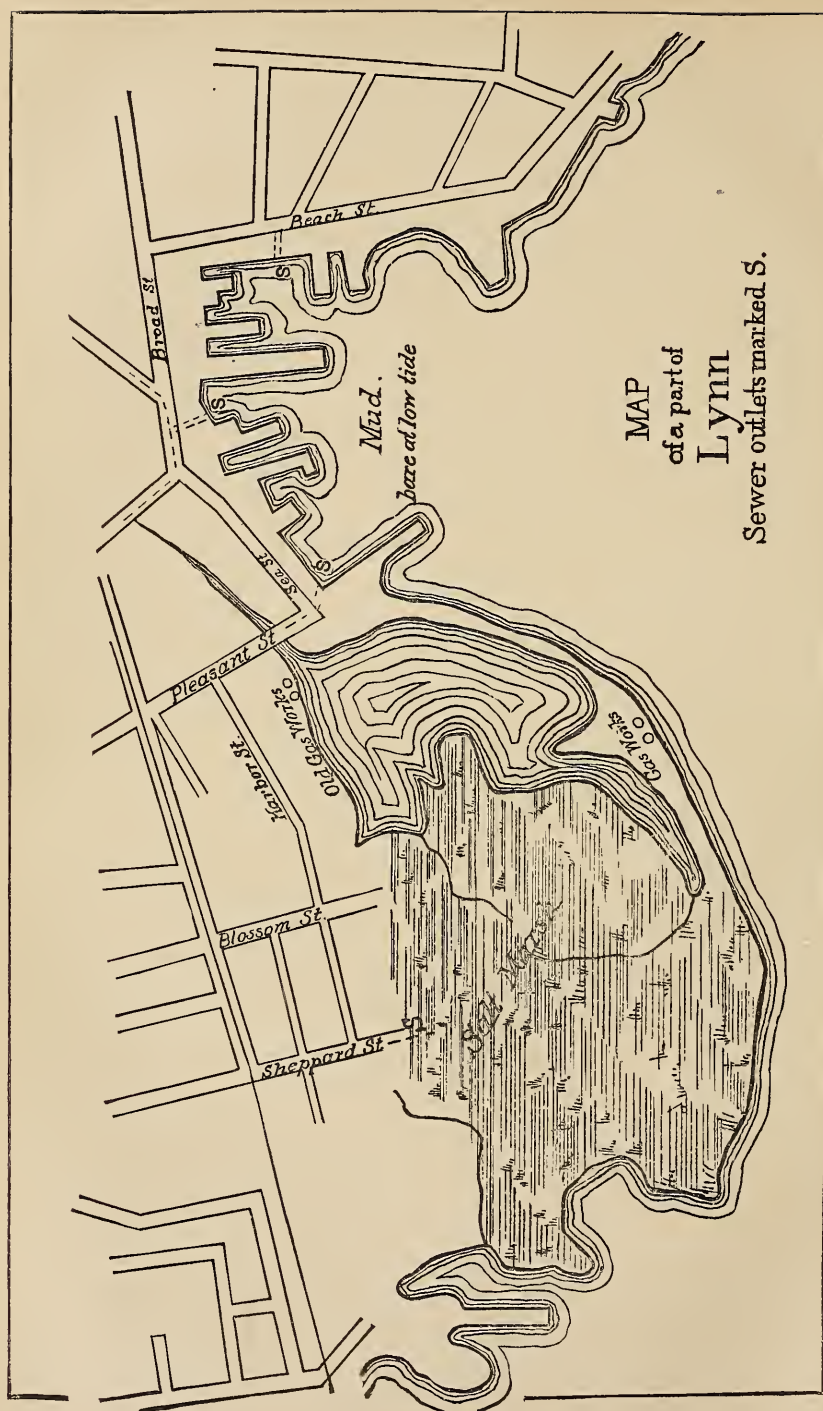
By comparing Nos. 5 and 9 with the analyses made in 1874, it will be seen that the purity of the water in Flax Pond has decidedly deteriorated during the past year. If a supply of water should be taken from this source for the city of Lynn, it is evident that the pond must be better protected from pollution than it is at the present time.

Prof. Nichols remarks, with regard to some of the specimens, as follows:—

“No. 7 was taken below a goat-skin factory, and is, no doubt, much contaminated. The character of the water must vary very much at different times, as is evident from the two samples. The first, taken November 11, was quite black, owing to suspended matter which settled slowly. This black matter seemed to be some sort of dyestuff, and the water was further remarkable for the small amount of ammonia. I should infer that some ‘emptying’ must have been going on at the time. The two samples could hardly have been suspected as coming from the same place. In the event of Flax Pond being used as a source of water-supply, this should be looked to, and the factory stopped. I do not think chemical examination alone can show that the pond itself is at present contaminated.

“Strawberry Brook (No. 10) and Silver Lake (No. 6) speak for themselves. The latter water was full of green matter, which, under the microscope, was seen to be made up of minute animals of low order, and vegetable matter in the state of decay (when received by me).

“Birch Pond water is strongly colored and highly charged with organic matter, which I think is mainly of vegetable origin. That some animal matter is derived from the overflowed meadow, and from the farm-house which is near the upper end, I have little doubt; but the amount cannot be great. I do not think that it can be positively said that the water is contaminated by sewage. Stacey’s Brook speaks for itself.”



“The emanations from the docks and flats have already been referred to. The stench in the neighborhood of these places is almost or quite unendurable, to one who has not become accustomed to it. Silver Lake is a constant source of foul odors during the summer season. The brooks are briskly running streams for quite a portion of the year, and do not become offensive to any great extent. The accompanying map gives the position of the sewer-outlets in the docks, and shows what must be the nuisance therefrom.

“Wet and damp cellars are very numerous, especially in the flat and undrained portions of the city; and they are sometimes found at the foot of our hills or high lands. Cases of typhoid fever, acute rheumatism, pneumonia, dysentery, diphtheria, croup, and chronic wasting diseases are more frequently observed in such houses than where the cellars and subsoil are dry.

“I would make the following suggestions:—

“*First.* That a definite plan be adopted for completing the system of sewers.

“*Second.* That the sewage be discharged into Saugus River, where it may be washed off into deep water; or carried out farther into the harbor, so that its solid portions may not be exposed during low water.

“*Third.* That drainage into the sewers, in all the densely populated parts of the city, be made compulsory.

“*Fourth.* That while waiting for the completion of the system of sewers, greater vigilance be used by the health authorities in looking after the condition of privies, and the disposal of sewage which runs on the surface. Said authorities are now, as they have been for many years, notoriously lax and inefficient.”

Salem.

“There have been four sources of complaint in this city* :—

“1. The defective sewer crossing the lots between Norman and Creek streets.

“2. The ‘mill pond’ in South Salem.

“3. The outlets of the sewers on the various water-fronts of the city.

“4. The use of North River, and streams emptying into it, as common sewers.

* Salem has already been referred to in connection with the subject of running streams used as sewers. A report of a special investigation, including map, by C. D. Ward, C. E., is now given, showing the many sources of nuisance to the inhabitants. The filth of Peabody, which is reported as not being a serious source of offence to that town, contaminates the air of Salem to a great degree.

“The first trouble is now done away with, a new sewer having been built in place of the old and defective one.

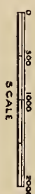
“*Second.* The mill pond covers in all some fifty or sixty acres. At its lower end there was formerly a tide-mill, and of course a narrow opening, with gates where the tide flowed in. This narrow opening remains, although the gates are no longer used. The Eastern Railroad crosses the pond twice. At the lower or northern crossing there is a bridge, with an opening fifteen feet wide; and at the upper or southern crossing a circular wooden culvert, five feet in diameter. Still farther south, Ocean Avenue crosses the eastern arm of the pond, leaving a space under the road about seven feet wide. Of course, these narrow openings interfere very much with the free ebb and flow of the tides.

“That part of the pond above Ocean Avenue contains four acres and a half, and receives the drainage from an area of about one hundred acres. Its bottom is covered with a layer of mud and sewage from three to six feet deep, a large portion of which is exposed for many hours each day, giving forth most offensive and dangerous exhalations. It is this part of the mill-pond alone of which serious complaint is now made; but the same condition may be expected in the lower portion also, in time, if nothing is done to prevent it.

“*Third.* There are in the city eight miles of public sewers, with twenty-four mouths or outlets. The majority of them empty at a level but little below high-water mark, where, the water not being very deep, the flats are soon left bare by the falling tide, retaining for a long time the filth deposited on them. Some of the sewers empty into coves and docks and ponds, where there is no current to wash away their deposits, so that a large portion of the sewage must remain where it is discharged, becoming the source of offence.

“*Fourth.* The nuisance most complained of is the use of the North River, and streams emptying into it, as common sewers. While the amount of sewage was small, and the volume of the water in the river large in comparison, there was no complaint of pollution; but now that the former has largely increased with the growth of business, and at the same time the river, instead of increasing, has been greatly diminished in capacity by deposits on its sides and bottom, there are loud complaints made by those living at a distance, as well as by those near to it, of the sickening stench which compel people at times to close their windows.

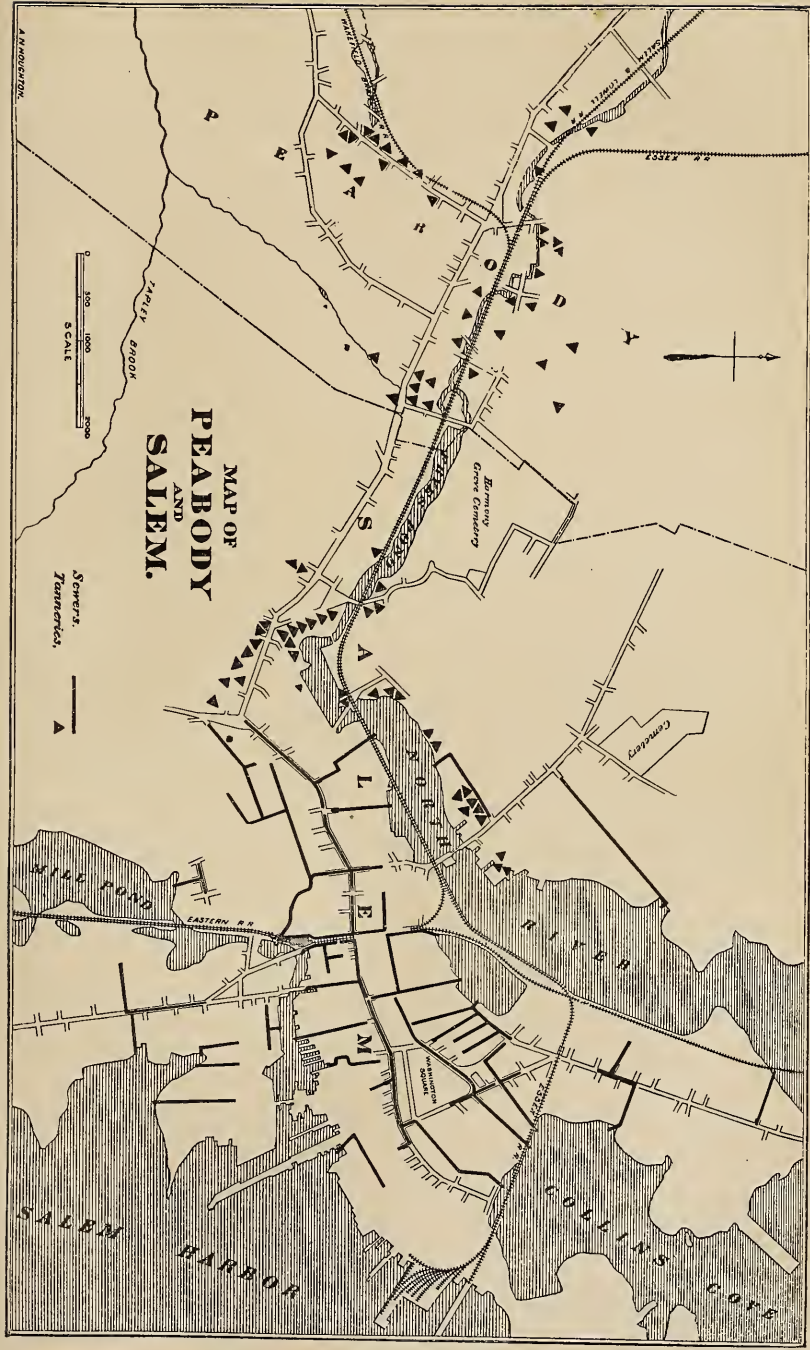
“Commencing the examination of the North River at its mouth, the current is there found running swiftly as the tide rushes in or out. Proceeding up the river, the channel soon narrows, so that at low tide the flats on each side are very wide and gradually rising, as refuse matter is deposited on them. The first bridge over the stream



Sewers,
Tunnels, ————



MAP OF PEABODY AND SALEM.



is about one mile from its mouth. There the river still farther contracts its channel, and becomes more crooked, with less depth of water. After passing a railroad bridge and one or two other small bridges in about three-quarters of a mile, we come to "Frye's Mill Dam," above which is a tide-mill with its dam and gates. The pond thus formed was formerly deep and held a large quantity of water, but it is now very much filled up with filth. It is nearly half a mile long, and, when full, averages one hundred and fifty feet wide; but, when empty, the channel is only from fifteen to twenty feet wide; leaving exposed a large area of filthy flats. The abominable odors caused in this way are the cause of the greatest complaint. From the head of this pond to the point where the next one formerly was in Peabody, about one-quarter of a mile, the stream is crooked and from eight to twenty feet wide, with banks but two or three feet above the water. Here the spring tides rise but one foot. In Peabody there was formerly a mill-pond, but it became foul and filthy to such a degree that it was filled up, and a channel was made for the stream between walls sixteen feet apart. Above this point the stream divides into two, Procter's and Goldthwaite's Brooks, which have more descent and less pollution.

"In Salem, eight sewers, with an aggregate length of 11,800 feet, empty into the North River. In Peabody, fifty houses are said to drain into it, beside the water-closets from twenty-eight tanneries, etc., employing eight hundred hands.

"There are three glue factories, one bleachery, one print-works, and fourteen morocco shops capable of tanning and finishing 2,736,000 sheepskins a year. The greatest source of pollution must be from the sixty-two tanneries, having the capacity of tanning 1,235,000 hides a year.

"These hides are twice soaked in salt or fresh water, in vats called 'soaking holes,' and then the fluid is allowed to run into the stream. This effluent is so foul that two samples were sent for analysis; one from a 'soaking hole,' where 150 hides had been soaked ten days for the first time; the other from one in which 175 hides had received their second soaking, lasting five days.

"It is estimated that of sample No. I. 8,646,827 U. S. gallons would pass into the river in a year, and of sample No. II. 9,340,665 gallons, excluding refuse from sheepskin tanneries.

"Twelve thousand bushels of hen-manure are used a year in the tanneries, and are allowed to pass into the river after having remained in the 'drenching vats' for some months, and become very strong.

"The area drained into the North River is fourteen square miles of comparatively low land.

"The population of this district was, in 1850, 12,835, and in 1870, 16,630.

The following table shows the composition of the waters referred to. The amount of pollution of the North River is seen to be enormous:—

Examination of Waters from Salem.

[Results expressed in Parts per 100,000.]

Number.	DATE.	LOCALITY.	Ammonia.	"Albuminoid Ammonia."	SOLID RESIDUE, UNFILTERED.			Chlorine.
					Inorganic.	Organic and Volatile.	Total at 212° Fahrenheit.	
1*	Aug. —, 1875,	North River, Salem,†		0.207	204.32	41.20	245.52	108.0
2	" —, 1875,	Salem, Tank No. 1,†		0.362	273.40	106.00	379.40	98.0
3	" —, 1875,	Salem, Tank No. 2, .		0.304	425.60	147.00	572.60	179.2

* Filtered gave inorganic, 204.52; organic and volatile, 40.40; total at 212° Fahrenheit, 244.92; but did not filter very clear.

† Very foul and stinking.

South Braintree.

More than a year ago, a petition was sent to the State Board of Health from fifty-six residents of the town of South Braintree, representing that disease had been caused by certain manufacturers lowering the waters of Little Pond in said town, so as to lay bare at several different times in each year, generally in summer, several acres of the bed of the pond, from which there arose exhalations injurious to health. The case was not one in regard to which the Board had any power; but they gave their opinion that the statements of the complainants were to some extent well grounded. The facts of the case are as follows :—

“As is indicated by the map, the town of South Braintree, containing about 2,000 inhabitants, is built along the southerly and easterly borders of a pond. The land is generally level in its vicinity, with a gentle slope towards the pond. The superficial soil is soft, and underlying it is a clay stratum of varying width, situated from one foot to several feet below the surface. Near the southeastern end of the pond, the average depth below the surface is one and a half feet. This is the portion near which nearly all the disease had its origin. The pond covers an area of about fifty acres; it is fed by the descent of the land and by one small stream only, which runs into it from the north. Here the land is swampy, covering a large number of acres. At low water, there are at least two small islands visible at the lower end of the pond, near the houses; and, at the same time, the borders near by, which are covered with water in the late winter, spring, and early autumn, are exposed to a very considerable width. At the angle of separation of the northerly and easterly banks, at this time, is situated a pool of water, at least an acre in extent, which is stagnant and filled with growing, rank vegetation. More than thirty years ago, a canal was built by owners of certain mill-property on the Monatoquot River, connecting the pond with the river; the object being to supplement the water-supply in times of drouth, and in midsummer. Two weeks are required to allow as much water as will, to flow out of the pond. This year (1875) the water was lowered five feet.

“Thirty years ago, there was scarcely a case of typhoid fever known in the town; whereas it was not an uncommon disease in the neighboring town of Randolph. In the last ten years, there have been here many cases of typhoid fever; every year a greater or less

number, in times of drouth. Till then, on the northerly border, the town was but little built up.

"The cellars of the houses of the greater portion of the town are apt to be damp; though a complaint of flooding of the same, has not been made. The water-supply is by means of wells for the individual houses, and the privies are in most cases detached from the houses, and not very near the wells; no case was found where the drain from the kitchen-sink was near the well. No unusual taste, as of sewage, has been noticed in the water of the wells connected with the houses where the diseases were most prevalent. The house where five fatal cases of cerebro-spinal meningitis occurred, was inhabited by three families, all rather filthy about the house. The people in the diseased locality kept their windows towards the pond open. Every evening in the autumn, from the middle of July to October, near the southern and eastern sides of the pond, the air was strong, with a peculiar bog-smell. In September, this year, it had been in that state, and was getting worse when the cases of typhoid came on. All appeared within a fortnight of each other, and in September.

"The memory of the reporter alone is depended on for these cases, and it was not accurately determined, whether or not defective water, etc., might have been at fault.

"The accompanying map illustrates the main points in the matter. The figures are explained in the following table:—

- "1. Two cases of typhoid fever this year,—one fatal.
2. Three years ago, three cases of typhoid fever,—two fatal.
3. One case of typhoid fever this year,—with recovery.
4. Two fatal cases of pneumonia last year.
5. Five fatal cases of cerebro-spinal meningitis, two years ago.
6. No tenants in summer months.
7. Two cases of typhoid fever, with recovery, this year.
8. One fatal case of typhoid, year before last.
9. Two fatal cases of typhoid this year.
10. Church twenty feet above level of water.
11. Islands at low water.
12. Stagnant and filthy at low water.
13. School-house."

Winchester.

The following account of the successful use of a gathering-ground as a source of water-supply, is given as furnishing information which may be of service to other towns.

Winchester (containing a population of 3,099) lies in the valley of the Mystic waters, the upper end of Mystic Pond

SOUTH BRAINTREE.



being within the southern portion of the town. It is partly in the valley-bottom, but mainly on the slopes of the bordering hills.

In 1872-3, there was appointed a committee to investigate and report upon the best means of securing a public water-supply. The necessities of the case seemed to restrict this committee to sources from which water must be raised by pumping, with all its attendant expenses, till it was suggested that on the top of the hills on the eastern side of the town there was a valley, in the neighborhood of which there were no buildings, and which might prove to collect from a rain-shed of sufficient area to supply the town by gravity flow. Examination was made and resulted in the selection of this locality for a storage-reservoir. The valley was drained by a small brook, never known to be dry more than two or three times in the last twenty-five years.* At its outlet the valley narrowed, so that only a comparatively short dam was needed. The engineers' levels showed that but forty dwellings in the town were above the head of the proposed reservoir. The depth of vegetable mould nowhere exceeded eighteen inches. This, with all shrubs and trees, was removed over an area of sixty acres, which was underlaid by hard-pan and ledge. The dam has a length of 675 feet; its greatest width is 130 feet; its width on the top is 13 feet; the greatest height is $30\frac{1}{2}$ feet.

The area of the reservoir is sixty acres; its length, 4,400 feet; greatest width, 1,450 feet; greatest depth, 23 feet. Since its construction the depth of water at the inlet-pipe (from reservoir to gate-house) has never been less than 15.87 feet. The total capacity of the reservoir is 259,000,000 gallons; which is capable of supplying daily at least 800,000 gallons, although the town does not now use one-quarter of that amount. The flow from reservoir to gate-house is so arranged that it can be taken at any point from the bottom to the surface of the water. During the first forty-eight days after water began to be stored (December 5, 1873 to January

* It was wholly on the known "rainfall to the acre" in Massachusetts, that the advocates of this plan based their confidence as to quantity, while as to quality they trusted to the fact that no source of pollution existed on the gathering-ground, or rain-shed.

22, 1874), 79,000,000 gallons were collected, and during the next thirty-six days, 53,000,000 gallons more were allowed to run to waste. The water-shed has an area of 425 acres. In quality this water will compare favorably with any in the Commonwealth. Its quantity can be doubled by uniting with it another similar gathering-ground in the immediate neighborhood. The entire cost, including thirteen* miles of main pipe, has been \$161,377, and this, be it remembered, is a *gravity* supply.

Worcester.

“Our water-supply is from a reservoir fed by Lynde Brook. It is generally considered that the health of the community has been improved since its introduction, although there are no available statistics to prove the fact.

“The sewered area includes the best part of the city; and, so far as it goes, our sewerage is satisfactory. The sewage is discharged into Mill Brook, which, for a long distance, has been converted into the main sewer. High water causes a backing-up at the outlet, and this locality is often very offensive. The spot is sparsely inhabited, and I know of no bad results to health traceable to this cause.

“In portions of the city where there are no sewers, arrangements for the disposal of filth are in part very primitive,—such as privies without excavation and surface disposal of sink-drainage. In other parts there are good cesspools. Some of the first-named localities are often and strongly offensive, and wells are, in some cases, exposed.

“In one house, I have this season attended both parents and one child with typhoid fever. Their well is twenty feet deep and thirty feet from the cesspool,—a shallow, unlined excavation. It is also twenty-five feet from the barn-cellar, where a sink-drain from the house discharges upon a small pile of manure. In another part of the city the filth from a long row of houses is thrown into a small branch of Mill Brook, turned for manufacturing purposes from the main channel, and rejoining it lower down. This region is perhaps the most sickly of the city, although there are other reasons also therefor.

“The outlet of our sewers is, properly speaking, that point where the main becomes an open stream, which it does in the city itself. For three-quarters of a mile it is open, has never been complained of so far as my knowledge goes, and is not supposed to have

* There are now fifteen miles, but the additional expense I do not know.

had any noticeable deleterious effect upon health. This sewer is eighteen feet wide and four to ten feet deep, straight in course, with a fall of one foot in one thousand. Its walls are built of stone, with a curved, paved bottom. It drains over sixteen miles of sewers. It is merely a new straight channel for Mill Brook. The old channel has not been entirely disused; a part of the water is still allowed to pass a break in the sewer-wall, and to follow its old winding course through a district called the 'Island,' thickly covered with tenement houses. This old channel still receives a large amount of sewage from privies placed over it, sink-drains, etc., and furthermore is the outlet for fourteen miles of sewers. Under these circumstances, the city is unable to shut off this stream without immediate very large expenditure in extending the system of sewers.

"As to what has actually been the effect of the present state of affairs upon the public health, there is no testimony of value."

The following extracts are from the printed report of C. H. M. Blake, C. E., City Engineer, Worcester, Oct. 25, 1875 :—

"About thirty acres of the Island district are extremely low, and not more than three and a half feet above ordinary water level of the Blackstone River at the outlet of the Mill Brook sewer. To drain this territory by gravity at that point, under existing circumstances, is impracticable; cellars that are now flooded during high water would not be relieved.

"The following schemes for accomplishing the object desired are submitted for consideration: First, by the passage of a grade-law, regulating the grades at which cellars and streets shall be built to insure perfect drainage. The expense of grading and raising buildings already constructed would be excessive, in comparison with other schemes.

"The second scheme contemplates the purchase of a portion of the water-rights of the Washburn & Moen Manufacturing Company, at Quinsigamond Village, and taking down about five feet of their dam at that point. This would insure proper drainage of the district, but is open to serious objections. The outlet of Mill Brook sewer is at present into a mill-pond; during low stages of water a portion of the bed of the stream is uncovered and exposed to the action of the air, the sewage-matter deposited undergoes a chemical change, which is offensive, and, in the future, as the population of the city increases, will become more so. To prevent the nuisance, it would be necessary to wall the channel of the river so as to contract the flow during dry weather, and prevent this deposit from taking place.

"The cost of this, added to the cost of water-rights to be acquired, would exceed the expense of the third scheme; which is, to carry a sewer to a point below the dam at Quinsigamond Village for an outlet. A sewer of the requisite capacity to carry the storm water of the Piedmont and Island districts would be of sufficient size to take the ordinary flow of Mill Brook sewer, in addition to the dry weather flow of the above districts. By an arrangement of gates, the dry weather flow of Mill Brook could, if desired at any time in the future, be diverted and carried below the dam, the waters during the wet season being discharged directly into the river, as at present.

"Another advantage of the third scheme is, that in case any of the numerous chemical processes on trial in Europe for the purification of sewage should prove practicable, or if irrigation or filtration should be resorted to as a means of purifying the effluent water, the sewage, during a large portion of the time, could all be concentrated at one point by gravity, where it could be dealt with at the greatest advantage. During freshets, no evil effect would ensue from the discharge of the Mill Brook sewer directly into the river."

At and below Northbridge, which is about fifteen miles below Worcester, neither the people living along the Blackstone River, nor the manufacturers, so far as could be learned, are annoyed by the condition of the water.

ANALYSIS OF VARIOUS WATERS.

Most of the chemical examinations given in this paper were made under the direction of Professor Nichols, in the laboratory of the Massachusetts Institute of Technology. The methods of analysis employed have been already stated on page 174.

In interpreting the results of the examination of a well-water, the most complete satisfaction would be gained by a comparison of the water of the well with what might be called the normal well-water of the particular region. Indications which would be proofs of contamination in one locality would awaken no suspicions in another.

For example, the natural waters in most places in this State are almost free from compounds of *chlorine*, which occurs in small amount in all waters, most often as chloride of sodium or common salt. Therefore, if any amount, at all considerable, of salt is found in a well-water not near the sea, it has come in some way or other from human sources,

and awakens suspicions of drainage. It may come from salt actually thrown into the pump in winter to thaw ice which has formed, or salt may have been applied on the surface of the ground to kill weeds. In each case its presence is accounted for naturally. More than one part of chlorine in 100,000 (0.6 grain per gallon) should awaken suspicion.*

The presence of *ammonia* or of nitrogenous organic matter, which is indicated by the "*albuminoid ammonia*," in a well-water to the amount in either case of 0.01 part in 100,000 (0.006 grain to the gallon), would point to the fact that the well was polluted by drainage, and even half that amount might awaken suspicion.

In the case of well-waters, little can be learned from what is called "organic and volatile matter"; more than three parts in 100,000 would certainly be ground for suspicion.

The presence of nitrates is generally proof that some drainage matters, or rather the products of their oxidation, reach the well. If the nitrates are accompanied by nitrogenous organic matter (as shown by the "*albuminoid ammonia*"), there is evidence that the well receives *fresh* drainage.

Water from streams or ponds must be very differently judged, and unless distinctly *bad*, cannot be passed upon by chemical analysis *alone*. Their borders and immediate watersheds must be carefully inspected. If they flow through or drain peaty soils, or contain "vegetable extractive matter," they will show under analysis more ammonia than belongs to a safe well-water, without falling under suspicion of contamination by drainage. On the other hand, there is normally very little chlorine in the water of streams and ponds, and, if we find the proportion of this approaching the limit named as safe in well-water (1.00 part in 100,000), we may be confident that it arises from sewage of some kind.

The fact that a water is clear and palatable is no proof whatever of its purity, these conditions being markedly present in some well-waters shockingly polluted with sewage, as shown both by ocular inspection and chemical

* The normal presence of considerable quantities of salt in the water of wells near the sea, is, of course, not to be overlooked. In a well examined at South Scituate, the chlorine, thought to be due chiefly to the immediate vicinity of the sea, amounted to nineteen parts per 100,000.

analysis; and further, a water may be found by the chemist to be fouled by sewage, and yet neither he nor the microscopist be able to say whether it carries the specific poison of certain diseases; for example, typhoid fever and cholera.

WELL-WATERS.

The following table contains the results of the chemical examination of well-waters received from various correspondents of the State Board of Health; others were examined, but, as they present no points of interest, they have been omitted.

Examination of various Well-Waters.

[Results expressed in Parts per 100,000.]

Number.	DATE.	LOCALITY.	Ammonia.	"Albuminoid Ammonia."	SOLID RESIDUE.			Chlorine.	Oxygen required to oxidize or- ganic matter.	Nitrates.	Lead.
					Inorganic.	Organic and Volatile.	Total at 212° Fahrenheit.				
1	Aug. 24, 1875,	Belchertown, . . .	0.0059	0.0044	20.76	1.80	22.56	3.56	0.11	Trace.	-
2	" 10, 1875,	Chicopee, . . .	0.0027	0.0069	45.92	4.60	50.52	11.72	0.08	Some.	-
3	" 31, 1875,	Clinton, . . .	0.0048	0.0072	28.68	14.88	43.56	5.26	0.13	Trace.	0.99
4	Dec. 9, 1875,	Lowell, } same well, {	0.1400	0.0140	*	*	77.20	20.60	-	Large amount.	}
5	" 27, 1875,	Lowell, }	0.1700	0.0140	*	*	69.92	15.50	-		
6	Sept. 9, 1875,	Malden, . . .	0.0059	0.0187	33.95	4.25	38.20	5.40	0.36	Consid- erable.	}
7	Aug. 24, 1875,	Milford, . . .	0.7253	0.0395	40.38	8.20	48.48	8.62	0.16		
8	Sept. 13, 1875,	Taunton, . . .	0.0037	0.0093	28.32	2.80	31.12	3.20	0.19	Trace.	-
9	" 13, 1875,	Taunton, . . .	0.1066	0.0136	43.12	1.80	44.92	10.20	0.15	Trace.	-

* The determination of the so-called "organic and volatile matter,"—that is, the loss on ignition,—would be of no value whatever in the presence of so much chlorine; the determination is of little value in most well-waters.

The following facts, with reference to the well-waters mentioned in the preceding tables, have been gathered from the letters of the various correspondents, and from Professor Nichols' reports :—

No. 1. *From Belchertown.* "There have been more cases of typhoid fever and diphtheria in the house where this well is, than in any ten, and I think twenty, houses I know of. I can see no reason for this, unless it is the water, and have reason to think this may be the cause.

"I should say the well probably receives indirect drainage, but cannot find in the results of examination anything to account for the sickness described."

No. 2. *From Chicopee.* "From a well in a house, where several cases of typhoid fever occurred this summer, and several cases a year ago, in the same house; a filthy yard, with bad drainage, we were satisfied was the principal cause, and believed the well was more or less contaminated. The yard has recently been drained."

No. 3. *From Clinton.* "I have several cases of lead-disease in families in the vicinity of the well."

Nos. 4 and 5. *From Lowell.* The drainage and sewerage of Lowell are as yet incomplete, and, in parts, very defective; and "filth diseases" are reported from the correspondent of the Board as being frequent in such localities.

"The water is from a well which is boarded over. Spittoons have been cleaned on the boards, and sink-water has been poured on the surface of the ground, about two or three feet from the well. The water is said to be hard, and all who have used it think it has a disagreeable taste.

"The first specimen, No. 4, of the water was taken when the condition of things was as just described. The second specimen, No. 5, was taken three weeks after the direct accession of fluid refuse had been stopped.

"The water, although clear to the eye, was offensive to smell and taste, and utterly unfit for domestic use. The second specimen was, in essential particulars, scarcely better than the first."

No. 6. *From Malden.* This would be pronounced a bad water.

No. 7. *From Milford.* "My attention was called to the condition of the water, while attending a case of sickness. . . . The well is located within the village, in low ground; is partly covered by a grocery store and partly under the street; has three lead-pipes entering it to supply families, . . . but is not supposed to be contaminated. The well has been used for the past seven years.

“This water is chiefly remarkable on account of the very large amount of ammonia. The water is not fit for domestic use.”

Nos. 8 and 9. *From Taunton.* The subsoil water of the denser portion of Taunton is probably considerably polluted, as the city is situated on flat ground, and has no complete system of sewerage. This was shown by an examination of water from a number of wells made by Professor Nichols for the city of Taunton, and by the examination of the two samples, Nos. 8 and 9, reported in the table. Neither of these waters is desirable for domestic use, and No. 9 is positively bad.

THE NEW WATER-SUPPLY OF SPRINGFIELD.

The new water-supply of Springfield is derived from a reservoir in the town of Ludlow, known as the Cherry Valley or the Ludlow Reservoir. A specimen of water taken from the reservoir, near the outlet, was sent for chemical examination, and the results are incorporated in the table which follows. The chief peculiarity was the presence of a large amount of vegetable matter. The water was filled with particles of a green substance, which proved on examination to be a species of vegetable, an alga belonging to the Nostoc family. The water, in the condition of the specimen sent, would seem undesirable for domestic use. Subsequently, Prof. Nichols visited the reservoir in company with the engineer, Mr. Phineas Ball, of Worcester, and specimens of water taken under direction of Mr. Ball from different localities were examined. The results are recorded in the following table. Prof. Nichols' remarks on the condition of the reservoir were as follows :—

“The Ludlow Reservoir, from which the city of Springfield proposes to take its supply of water for domestic use, is formed by damming up several brooks, tributaries of the Chicopee River. The details of the location and construction of the reservoir, are given very fully in the report of the board of water commissioners of the city of Springfield, 1875. The reservoir covers an area of about 450 acres. Much of the land on which it is built was under a good state of cultivation, as pasturage, grass and tillage land. On the southern and south-eastern sides are large areas of gravelly and sandy soil, and some 280 acres were covered with wood in various stages of growth. A portion of the timber-land was on a swampy bottom. The shores of the reservoir are of an unobjectionable character. In preparing the reservoir for flooding, the timber and brush

were cut down and the ground burned over, the stumps which were left standing being thoroughly charred. A portion of the swampy area was covered with sand and gravel. The reservoir is now (September 7) mainly completed, but not yet full; it will fill during the coming winter. The water was collected to the present height in the spring, and the amount used and that lost by evaporation have been equal to the supply. Hence, there are about 100 acres of the muddy or swampy bottom now covered with only a few feet of water, where, after the reservoir is full, there will be from 12 to 16 feet of water; there will then be only a few acres (perhaps 25) of shallow water, and that will be at the upper end, where the bottom is good. The water is now used for watering streets, and for watering cattle, etc., in Springfield. It is also supplied to a limited part of the city for domestic purposes. The water had a marked, peculiar taste and odor of green corn, which seemed to be closely connected with, if not caused by, the vegetable growth which was observed. The chemical examination of the water showed the presence of a large amount of nitrogenous organic matter, a considerable portion of which is to be ascribed to the decaying of vegetable matter. I think, however, this is a temporary condition of things which will very sensibly improve as time passes. With reference to the living vegetable matter already alluded to, it is to be said that there will probably never again be so favorable an opportunity for the growth of low orders of animals and plants as was presented this summer in the large amount of shallow water exposed to the sun's rays. . . . It will further appear from the table, that the water dissolves a considerable amount of mineral matter from the cement-lined service-pipes. This is, however, no serious matter, and probably the proportion so dissolved will be less after the pipes have been longer in use."

The results of the examination of specimens of water, collected in December, 1875, and January, 1876, are published in the second report of the water commissioners, and are introduced into the accompanying table.

The reservoir is now nearly full, and it will be seen that a great improvement has taken place. The water is now nearly free from suspended matter, and without any disagreeable odor or taste.

Examination of Water from Ludlow Reservoir.

[Results expressed in Parts per 100,000.]

Number.	DATE.	LOCALITY.	Ammonia.	"Albuminoid" Ammonia.	SOLID RESIDUE.			Chlorine.	Oxygen required to oxidize or- ganic matter.
					Inorganic.	Organic and Volatile.	Total at 212° Fahrenheit.		
24 M	1875. Sept. 2,	Between filter-dam and gate-house, { Unfiltered,* Filtered,* .	0.1227 0.1333	0.3627 0.0773	4.20 3.92	10.72 3.56	14.92 7.48	- -	- 1.37
26 M	" 9,	Midway between filter-dam and gate-house, { Unfiltered,† Filtered,† .	- 0.1066	- 0.0666	3.36 3.48	3.68 3.44	7.04 6.92	- 0.24	- 1.39
27 M	" 9,	Middle of reservoir, { Unfiltered,† Filtered,† .	- 0.1040	- 0.0666	2.72 2.96	4.48 3.92	7.20 6.88	- 0.22	- 1.43
28 M	" 9,	Service-pipe, Indian Orchard, { Unfiltered,† Filtered,† .	- 0.1333	- 0.0660	6.68 6.32	3.84 3.88	10.52 10.20	- 0.34	- 1.51
29 M	" 9,	Service-pipe on hill, { Unfiltered,† Filtered,† .	- 0.1066	- 0.0720	7.16 6.40	3.68 3.76	10.84 10.16	- -	- 1.48
32 O	Dec. 25,	Reservoir near entrance of Broad Brook,† .	0.0084	0.0172	3.60	2.16	5.76	0.20	0.82
33 O	" 25,	Middle of reservoir,† .	0.0162	0.0314	3.52	2.88	6.40	0.21	1.31
34 O	" 25,	Between filter-dam and gate-house,† .	0.0162	0.0320	3.36	2.92	6.28	0.22	1.45
36 O	1876. Jan. 17,	Middle of reservoir,† .	0.0126	0.0316	2.64	2.44	5.08	0.20	1.33
38 O	" 17,	Middle of reservoir, second sample,† .	0.0152	0.0318	2.40	2.64	5.04	0.20	1.49
37 O	" 17,	Between filter-dam and gate-house,† .	0.0120	0.0340	2.46	2.98	5.44	0.20	1.29
35 O	" 17,	Broad Brook,† .	0.0066	0.0128	3.14	1.88	5.02	0.20	0.89

* Collected by Dr. Smith, Granby.

† Collected under direction of Phineas Ball, Esq., Engineer of the Springfield Water-Works.
‡ These examinations were made for the city of Springfield. The water was collected by, or under direction of, Mr. Ball.

THE PITTSFIELD ICE-SUPPLY.

Nearly all the ice used here is cut on "Silver Lake," which is about twenty acres in extent, and situated to the eastward of the more thickly-settled portion of the town. Its outlet into the Housatonic River ordinarily discharges but little water, and the flow is sometimes even toward the lake, which is fed by springs and a small brook, which takes its rise in Frog Pond, about half a mile to the north. The sources of pollution on the brook are several dwellings and two factories, —the one discharging a small amount of refuse dyestuff from silk-works, the other emptying the overflow of a cesspool for water-closets, used by one hundred and fifty employés. According to Dr. Adams, health officer of Pittsfield, the water is sometimes quite foul in appearance, but oftener comparatively clear. Looking upon this source of pollution with some suspicion, he sent specimens of water for analysis. Prof. Nichols afterwards visited the locality, at the request of the Secretary of the Board, and obtained several more. From the results of analysis, it will be seen that the ice is considerably purer than the water of the pond, thereby showing that the process of freezing does tend, to a considerable degree, to purification. Chemical examination alone does not indicate that the ice is unfit for domestic use, nor does it ordinarily detect a very slight degree of pollution, which may be offensive to our sense, from the fact that we previously knew of its presence.

Considering the great dilution of filth which may often take place without securing immunity from disease consequent upon taking such filth into the system, there can be no question as to the propriety of putting a stop to this contamination at once, especially in view of the fact that it is likely to increase rather than diminish.

The large amount of inorganic matter is thought, by Prof. Nichols, to be due to mineral salts dissolved in the waters of the springs, which indeed have been found hard and unfit for use in boilers.

There are a few dwellings, and a shoe-factory, on the borders of the lake itself.

Examination of Water from Pittsfield, Mass.

[Results expressed in Parts per 100,000.]

Number.	DATE.	LOCALITY.	Ammonia.	"Albuminoid" Ammonia.	SOLID RESIDUE.			Chlorine.
					Inorganic.	Organic and Volatile.	Total at 212° Fahrenheit.	
74	Feb. 21, 1876,	Frog Pond, ¹	0.0072	0.0212	2.64	2.44	5.08	0.04
75	" 21, 1876,	Brook, ²	0.0180	0.0120	18.08	2.28	20.36	0.36
67	" 16, 1876,	Brook, ³	0.0140	0.0180	9.58	2.78	12.36	0.21
58	Nov. 21, 1875,	Brook, ⁴	0.1400*	0.0348	16.64	4.64	21.28	0.67
68	Feb. 16, 1876,	Brook, ⁴	0.0060	0.0156	9.06	2.84	11.90	0.18
59	Nov. 21, 1875,	Lake, ⁵	0.0210	0.0200	10.28	2.60	12.88	0.26
69	Feb. 16, 1876,	Lake, ⁶	0.0180	0.0152	10.32	2.72	13.04	0.30
70	" 16, 1876,	Lake, ⁶	0.0220	0.0140	11.92	2.60	14.52	0.35
71	" 16, 1876,	Lake, ⁷	0.0200	0.0136	11.60	2.68	14.28	0.38
76	" 21, 1876,	Ice from lake, . . . { Unfiltered, . . .	0.0072	0.0061	0.93	0.58	1.51	—
			0.0077	0.0013	0.30	0.14	0.44	0.02
72	" 16, 1876,	Housatonic River, . . . { Filtered, . . .	0.0042	0.0089	4.84	2.64	7.48	0.11

* Unfiltered gave ammonia, 0.1400; "albuminoid ammonia," 0.0520.

¹ Taken near the middle of the pond.

² Taken just above drain from silk factory.

³ Taken at eastern end of pond, midway between north and south shores, at surface.

⁴ Taken at same point, near bottom, fifteen feet from surface.

⁵ Taken from bottom of pond at west end, thirteen feet from surface.

⁶ Taken at Lincoln Street bridge, some distance above silk factory.

⁷ Taken between silk factory and lake.

III.—THE DISPOSAL OF SEWAGE.

By C. F. FOLSOM, M. D.

INTRODUCTION.

After the loss of the water-closet in the destruction of Pompeii, the disuse of the bath upon the overthrow of the Latin civilization, and the entire oblivion of the lessons taught by the sewers of Rome, Jerusalem, Pompeii and Nineveh, human filth was allowed to accumulate around the towns and cities of Europe until the inhabitants, in seasons of unusually bad climatic influence, were decimated by the black death* and the plague. They were taught their first lessons in sanitary science by their Mohammedan enemies, and more attention to cleanliness made the two dreaded diseases almost unknown.

In modern times it has been easy enough to think that in the darkness of the Middle Ages people poisoned themselves with their own filth, and therefore suffered terribly from the ravages of preventable disease; but all communities have been slow to believe that the more familiar diseases, like scarlet fever and typhoid fever, which they had been in the habit of considering more or less inevitable, were perhaps not equally preventable with cholera and typhus, but still preventable to a very great degree; and it was with surprise that people not educated in medicine heard, during the past year, that one of the first authorities now living had described a large class of maladies as "filth-diseases."†

It has been difficult to explain why an intelligent appreciation of disease, and a reasonable knowledge of the ordinary means of its prevention, have been so slow in forcing them-

* Hecker [Epidemics of the Middle Ages] estimates that in the first epidemic of the fourteenth century this disease swept away one-fourth of the total population of Europe; other writers place the mortality at a still higher figure.

† Second Report of the Medical Officer of the Privy Council, new series. London, 1875; reprinted by permission of the author, Boston, 1876.

selves upon the attention of all communities. Nearly three-quarters of a century passed in England, after the discovery of the means of preventing the scurvy, before they were sufficiently appreciated to be used in the royal navy; and only a year ago it was preached from one of their pulpits that the severe epidemic of scarlet fever in London was a visitation from God for the sins of the wicked metropolis. The small-pox epidemic of 1872 found most of our cities in America entirely unprepared to meet it; and it was only with great difficulty, and against much opposition, that proper steps were taken to control the disease.

For the past third of a century, however, more persistent efforts than ever before have been made to improve the health of the people; the social economist has outdone the novelist in his computations of the suffering and misery, the waste and loss to society, arising from this cause, that might be avoided;* and the statistician, with his estimate of twenty to twenty-eight cases of illness for every death, has added his warning. Much has already been done; human life has been prolonged; diseases that formerly were common have disappeared, while others have materially diminished, all from a better attention to cleanliness.

Complicated as has been the sanitary legislation of different countries, it resolves itself chiefly into the broad principle of attempting to provide clean air, clean water, clean food, clean soil, clean houses. It is not to be understood, however, that any *general* attention to cleanliness, in the ordinary acceptation of the word, will secure entire immunity from the preventable diseases. The special *kinds* of cleanliness necessary to avoid the different fevers, for instance, are quite different one from another, and cannot be fully practised without an intimate knowledge of the way in which each disease is propagated.

Twenty-five years ago, preventive medicine consisted in trying by quarantine to keep out disease: now it consists chiefly in removing the conditions favorable to its existence and spread. The Act appointing the Central Board of Health in London recognized this fact, and stated that "the measures

* See Dr. Richardson's lecture, "A Model City of Health," delivered before the British Social Science Association, in Bristol, October, 1875.

of extreme precaution for preventing the introduction of the cholera by a vigorous quarantine, have hitherto been found inefficient." Pettenkofer puts the matter still more forcibly. He compares the outbreak of cholera to explosions from gunpowder. The sparks which set fire to the powder are the "germs" of the disease, which we cannot keep out by the most rigid quarantine; the powder is the combination of local circumstances in a town or city, without which the disease cannot get a foothold. He says that we "act more wisely in searching out and removing the powder itself, than in running after and trying to extinguish each individual spark before one of them drops on a powder-heap, and causes an explosion which blows us into the air with our extinguishers in our hands."

The general intelligence of any community may be safely inferred from the attention which they pay to removing all filth—one link, at least, in the chain of disease which we *can* control—completely away, beyond the possibility of doing harm.

THE EFFECT OF FILTH ON HEALTH.

Dr. William Stokes, one of the first authorities in sanitary science, says: "Sewers, streams, rivers and damp localities, collections of refuse,—not alone of putrefying animal and vegetable matters, but of materials in no way offensive,—have been in turn accused as having been manufactories of disease, not of cholera alone, but, in an enterprising mercantile spirit, of a great variety, so as to suit the market."*

Dr. Pratt says of a district in the north of Ireland: "If dirt alone was the common generator of fever, the country would long since have been desolated from sea to sea;" whereas fever is there almost unknown. In one place in that country four thousand persons were found living on twenty-five acres of land, each house having its dunghill, and even the lower rooms of some of them being filled with manure; yet the health of the town has always been good.†

* Lecture on Sanitary Science, 1873.

† Probably no one cause is more prolific of disease than density of population, with its concomitant evils, the greatest of which is, usually, incomplete removal of filth. This is shown, with remarkable force, by the statistics of

Dr. Graves says: "Filth is the outward and visible sign of poverty, and, like poverty, is an evil in itself; it oftener accompanies than causes disease; otherwise, as I have said, every capital in Europe would contain within its precincts many self-supporting manufactories of pestilence. I have always been of opinion that poverty is more injurious to

England for the different registration districts, in the decennial period from 1851 to 1860.

Table showing the effect of Density of Population on Death-rates in England.

NUMBER OF DISTRICTS.										No. of Acres.	Average Population.	No. of Persons to each square mile.	Annual death-rate per 1,000.
1,	.	.	.	.	.	.	.	.	.	238,861	6,817	18	14
2,	.	.	.	.	.	.	.	.	.	301,473	21,069	45	15
12,	.	.	.	.	.	.	.	.	.	627,588	129,005	132	16
26,	.	.	.	.	.	.	.	.	.	1,507,484	421,140	179	17
81,	.	.	.	.	.	.	.	.	.	5,258,236	1,300,629	158	18
121,	.	.	.	.	.	.	.	.	.	9,540,681	2,668,756	179	19
129,	.	.	.	.	.	.	.	.	.	8,444,479	2,649,736	201	20
84,	.	.	.	.	.	.	.	.	.	5,599,983	2,110,379	241	21
51,	.	.	.	.	.	.	.	.	.	2,636,106	1,878,056	456	22
40,	.	.	.	.	.	.	.	.	.	1,514,137	1,845,790	780	23
26,	.	.	.	.	.	.	.	.	.	590,955	1,762,962	1,909	24
20,	.	.	.	.	.	.	.	.	.	442,540	880,953	1,274	25
14,	.	.	.	.	.	.	.	.	.	217,029	1,065,319	3,142	26
13,	.	.	.	.	.	.	.	.	.	212,694	1,085,675	3,267	27
11,	.	.	.	.	.	.	.	.	.	195,673	1,170,740	3,830	28-33
Total No. of Districts, 631, ...										37,324,883	18,997,076	362	22

The fallacy, however, of trying to explain high rates of disease or death by any one cause, is well shown, in connection with this table, by the experience of Glasgow and Greenock, two Scotch cities only forty miles apart. For the ten years ending in 1871, the average death-rate per 1,000 of Greenock was 33.6, against 30.6 in Glasgow, in spite of the facts shown here in tabular form:—

CITY.										Total Population.	Population, per acre.	Population, per house.	Daily water-supply per person, in gallons.
Greenock,	.	.	.	.	.	.	.	.	.	59,785	24.4	27.4	53.6
Glasgow,	.	.	.	.	.	.	.	.	.	477,710	94.9	32.5	54.0

This simply shows that other causes of disease may be so potent as to overbalance that of density of population. Greenock, the port of the Clyde, naturally has a larger proportion of the improvident classes than Glasgow; its sewerage is in a much worse condition; it is much more exposed to sea-winds; it has a rainfall sixty per cent. greater, and, in proportion to its population, has two and a half times as many cellars used for lodgings.

health than dirt; that its prevalence entails disease,—sporadic disease,—from many obvious causes, and increases its spread.”

There is among men a tendency to attribute complex phenomena to a single cause; and, much as we have learned with regard to the “preventable diseases,” there is still too much truth in the statement that “the causes of epidemic diseases escape the scrutiny of both nostrils and vision.”

Virchow thinks* that ordinary putrefaction may, under certain circumstances, all of which are not known, produce some of the zymotic diseases, especially typhoid fever and dysentery. Pettenkofer holds that a specific poison exists for those diseases, and that each disease can be produced only by its own virus or germ. In England, where Pettenkofer’s theory of the relations of the variation in the level of the ground-water to typhoid fever and cholera has not received general support, opinion is divided, as it is on the continent of Europe, as to the question whether disease is produced by filth alone, or by filth *plus* some particular poison. Continuing the comparison previously cited, Pettenkofer likens urban filth to the charcoal in gunpowder. *It is necessary to have it, in order to produce the explosion;* but the sulphur and salt-petre must be there, too, and the mixture must be in the right proportions; otherwise, the spark produces no fire.

Liebermeister’s opinion† seems to be gaining ground; namely, that filth furnishes a favorable *nidus* in which disease finds favorable conditions for rapid development.

The fact, however, stands unquestioned, that in some way or other removal of filth lowers death-rates. Berlin and Munich, the filthiest and most scientific of the German cities, deserve Traube’s sarcasm of not being able to stop the cholera, even in winter,—a more or less continuous epidemic, so to speak, having lasted since 1866; while in London and Paris, the cleanest of large cities, the last epidemic (in 1866) fell very lightly, and the death-rates are one-third lower than in Munich and Berlin. In Hamburg and Dantzic, the only German cities where systematic sewerage-works have been completed for several years, the increased cleanliness

* This subject is fully and exhaustively discussed by him in his lecture on “*Die Fortschritte der Kriegsheilkunde.*” Berlin, 1874.

† “*Zur Aetiologie des Typhus.*” *Deutsche Klinik*, February 17, 1886.

has reduced the mortality in a great degree. In Dantzic, typhoid fever has become chiefly a disease of the suburbs, where there are no sewers.

In England, the reports of the medical inspectors to the medical officer of the privy council have contained such searching investigations of the causes of disease, and their connections with filth, as to give to at least one branch of medicine the title of an exact science. One of the most striking of these papers,* by Dr. George Buchanan, shows the improvement to health from drainage, sewerage and water-works, in twenty-five cities and towns, with an aggregate population of 593,736. The average of the death-rates per 10,000 for the different places had decreased as follows:—

From all causes, ...	from 247.55 to 219.87
typhoid fever, ...	“ 13.34 to 7.8
diarrhœa, ...	“ 8.45 to 7.66
pulmonary consumption, . .	“ 33.44 to 27.3
Among infants under 1, . .	“ 55.65 to 50.

The average number of years for which the death-rates were calculated, were, before improvements, seven and one-half; after them, six and five-eighths.

Dr. Buchanan's final conclusion from his investigations was, that the progress made by the inhabitants of most of the twenty-five towns, in decency, cleanliness, self-respect and morality, was, at the least, as striking as the improvement in the health, measured by the mortality returns. The increased self-respect and improved general condition, undoubtedly led them to a juster appreciation of disease, and of measures to prevent it.

In some of these towns, it was found that improper construction or ventilation of the sewers had been the probable cause of increasing the death-rate, by exposing people to the direct effect of deleterious gases.

THE INFLUENCE OF SEWER-GASES ON HEALTH.

With regard to the effects of sewer-poison, it is found that its virulence depends in some measure on the age, condition,

* Ninth Report of the Medical Officer of the Privy Council, p. 50.

habits and employment of the persons exposed to it, and also upon the freshness of their exposure. Many facts go to show that an atmosphere may be tolerated in working hours which would produce serious disease if breathed when the system is in the non-resistant condition of sleep. In the same way, when the system is fresh, in active exercise, and well nourished by abundant food, one may safely expose himself to a degree of contamination of the air which would be thoroughly unsafe if the various organs of the body were relaxed by sleep, fatigue, or even a posture of rest.* Illustrations of this fact are numerous. Carpenter states that a large number of children in one of the English workhouses were twice attacked with severe diarrhœa from exposure to the emanations from a manure factory, while the workmen had good health. Murchison relates that in a school at Clapham, twenty out of twenty-two boys were seized with violent vomiting, purging, prostration and fever, within three hours after exposure to foul sewage-emanations rising from a sewer which they had been watching the workmen clear. None of the men became ill.†

It is undoubtedly the same with regard to sewage-emanations in and near our dwellings. The strong, the active, the well, and those who spend a large part of the day away from their houses, do not ordinarily suffer. In the great epidemic of typhoid fever at Croydon, in 1853, caused by sewer-gases in the houses, "we found servants chiefly attacked, and then children; the fathers were very seldom sick at all, because they were not much at home, while the others were usually at home."‡

It is most often from long-continued exposure, or when some depression of the vital powers exists, that disease is caused by a sewage-poisoned atmosphere, unless the poison be very concentrated.§

* These facts are well known to inhabitants of malarious districts. They do not hesitate to walk or ride, especially after eating, through regions where they could not sleep, or even drive, with impunity.

† The six hundred workmen in the thoroughly-ventilated sewers of Paris are generally exempt from zymotic diseases, as has been shown by severe epidemics in the city at various times. They suffer chiefly from chronic diseases, indicative of slow rather than rapid poisoning.

‡ Evidence of Dr. William Sunderland.

§ A number of authentic cases show the danger of these poisons when con-

It is a well-known fact, too, that by long use we are able to tolerate certain conditions unfavorable to health. This really means, however, in a large proportion of cases, that the injurious effects are so gradual in their manifestation that we do not appreciate them.

The influence of sewage upon the water-supplies of cities, has already been fully considered in previous pages of this Report. A few words will be in place here in regard to the chances of contracting disease from drinking such water, after it has been subjected to the various processes of purification, etc.

WATER CONTAMINATED BY SEWAGE.

It has been stated by an eminent English authority, that streams become purified by a flow of twelve miles if not more than one-twentieth part of their volume has been made to consist of sewage; and that it is safe to drink sewage-contaminated water after filtration.

Much, indeed, has been said as to the complete self-purification of rivers by a flow of a few dozen miles. No such power exists. The solid parts are deposited, and what remains looks clear and bright, especially when largely diluted. Chemical changes take place, too,—sometimes decomposition, sometimes putrefaction, sometimes simple elective combinations. If sewage contain the "germs"* of disease, whatever they may be, no agency at present known, except a sufficiently high temperature, will efficiently destroy them.† Excessive dilu-

centrated. In the memorial of the Rotherham and Kimberworth Board of Health to the English parliament, February, 1865, it is stated that the annual mortality was as great as forty in one thousand; "and the memorialists believe that the emanations from the great filth in the River Don is mainly the cause of the sickness and mortality that have prevailed, and which, to the belief of your memorialists, cannot be accounted for in any other way." The Rivers Pollution Commission attributed the great mortality from cholera in East London, in 1866, in a great degree, to the emanations from the sewage laid bare at low tide on the exposed banks of the Lea; although the contaminated water-supply was probably the chief cause.

* The word "germ" is used in this paper in its general sense, as indicating the matter which causes disease, whatever its origin, whether specific or not.

† This was the unanimous decision of the International Medical Congress at Vienna in 1874; and the same statement is made repeatedly, in various forms, by the Rivers Pollution Commissioners of England. In their last report (1875, p. 283), they say: "Slow soakage through a few feet of gravel destroys more organic matter than does a flow of many miles in the

tion simply diminishes the chances of danger from any particular tumblerful.

The most striking case illustrating this law, is one reported by Dr. E. D. Mapother, of Dublin. Forty cases of typhoid fever occurred in a hospital which received its water-supply from a river. The cause was traced to some barracks *twenty-five miles* higher up, from which typhoidal dejections had been emptied through drains into the river.

It is not known how long is the duration of life, and of the power of communicating disease in these "germs." Some authorities suppose that, like most low organisms, they perish in a comparatively short time; others think that they remain active for a long time; still others hold that certain epidemics can be explained only on the theory that the "germs" are even capable of rapid multiplication under favorable circumstances. As to what these "germs" are, we can, in the present state of science, only say, with Pettenkofer, that we "do not know." Observations* in Munich in 1866, and in Syria in 1875, have convinced Prof. von Pettenkofer that the poison [*keim*] of cholera at least may remain inactive even several months before giving rise to an outbreak; and hence the theory with certain observers, that this period of inactivity is necessary for their development into disease-producing organisms. As to the "spore-theory" of Pasteur and others, it can only be said that the *bacteria*, etc., found in the various infective diseases, whether they are different or not, cannot yet be distinguished from one another, and from those found in healthy persons. Billroth makes them all forms of one mother-plant, the *Coccobacteria septica*. Their connection with destructive decomposition of organic matter; *i. e.*, with filth, is well known. How far they are connected

Thames." The Irwell River, after leaving Manchester, runs eleven miles without further pollution of any consequence, and passes over six weirs; yet the purification is trifling. The same was found to be true of the Mersey and the Darwen.

By siphoning water from one vessel to another, so as to represent a course of ninety-six miles, experiments in England showed that the organic carbon was reduced only 6.4 per cent., and the organic nitrogen 28.4 per cent. By similar experiments, representing a flow of one hundred and ninety-two miles, the reduction was respectively 25.1 and 33.3 per cent.

* *Der. tliches Intelligenz-Blatt*, Munich, January 6, 1876.

with the *production* of disease, if at all, must be decided by future investigations.

EXPERIENCE IN ENGLAND.

England stands at the head of the nations of the world in the matter of sanitary legislation. With a dense population confined on a narrow island, often collected near small streams, and with a law which keeps the land in the hands of a few, and crowds the laboring classes into the smallest space, a condition of filth formerly existed in many of the homes of the very poor* which we have seen only exceptionally in this country, and then in our largest cities.

In this country, the places have been, until quite recently, comparatively few where the evils of overcrowding and filth have been great. Generally speaking, we have had such an immense volume of air and water in which to dilute the filth of our towns and manufactories, that we have not been obliged to breathe and drink, in a concentrated form, the poisons whose existence has made sanitary science a necessity in England for many years. That we have fairly begun to suffer such evils, however, is becoming every day more and more apparent.

The first attempt at sanitary legislation in England, was the law of 1388, imposing fines upon those who cast filth into rivers and ditches. In 1489, slaughtering was prohibited within cities. Shakespeare's father was twice fined for violating the law concerning the removal of filth. Under Henry VIII., James I. and George II., special sanitary Acts were passed† to meet special exigencies, such as the outbreak of the plague.

In 1817-19, an epidemic of fever raged in Ireland, during which a million and a half of cases occurred, with sixty-five thousand deaths. More than one-sixth of the population of

* Compare a "Report on the Sanitary Condition of the Laboring Classes in Great Britain," by Mr. Edwin Chadwick, London, 1842; the first important contribution to sanitary literature in Great Britain, and one which did incalculable good in directing public attention to the evils of the conditions under which the masses were living. Mr. Chadwick computed that the "annual slaughter" in England, from typhus fever, a preventable disease, was greater than the loss sustained by the allied armies at the Battle of Waterloo.

† The Law Magazine and Review, London, November, 1875.

Dublin was treated in the hospitals alone; and, under the stimulus of such a pest, an Act was passed, in 1818,* authorizing the appointment of boards of health, and giving them great power.

The outbreaks of the cholera in 1831, 1849, 1854 and 1866,† hastened legislation so much, that Acts were passed one upon the top of another so rapidly, that the greatest confusion existed for many years; and even skilled lawyers found difficulty in ascertaining what was the law. The administration was naturally very defective. To consider means for consolidating all these Acts into one, the Royal Sanitary Commission was appointed in 1869, and the Public Health Act, of 1875, was the result of their labors. The commissioners say, in their first report: "Sanitary legislation has been remarkably drawn out by, and connected with, these outbreaks of cholera, which led to investigations of the means of preventing infectious diseases, and so drew attention to the fact that *the seats of endemic diseases are generally where the air or water is polluted.*" That is to say, the whole general sanitary legislation of England, for thirty years, has been chiefly directed to the removal of filth. Under these circumstances, the importance of the part played by filth, in producing disease, may, perhaps, be overrated in that country, and the part played by other causes, underrated.

The report of Mr. Chadwick, made by him as secretary of the Poor Law Board, in 1842, has been already referred to as the first public contribution to the cause of improved sanitary legislation; although Dr. Rumsey and others had done much privately, and the government had prepared the way for such investigations, and had directed attention to the prevention of disease, by the facts collected under the Act for the registration of births and deaths, passed in 1836.‡

In 1843, Mr. Chadwick published his supplementary report

* Furlong on Sanitary Legislation.

† If the Acts requiring water-companies to go higher up the river for their supplies, to furnish water uncontaminated by London sewage, and to filter it, had been passed before the cholera raged, in 1849, there can be no reasonable doubt that at least five thousand lives would have been saved, in that and the succeeding epidemics.

‡ The provisions of this Act were extended to Scotland in 1854, and to Ireland in 1864.

on the evil effects of intramural interments, and in the same year the Health of Towns Commission was appointed, under the Duke of Buccleuch as chairman. Their two exhaustive reports on the state of large towns and populous districts, and on the remedial measures which should be adopted, brought to light such a mass of evidence as to the bad sanitary condition of many of the towns in England, that the way was opened for the Public Health Act of 1848, and for the appointment of the General Board of Health. In 1847 and 1848, the Metropolitan Sanitary Commission published their three full reports. The four reports of the General Board of Health, in 1852 and 1854, contain a mass of information in regard to the sanitary state of England, especially on the subjects of sewerage and the disposal of sewage.

The three reports of the Sewage of Towns Commission; the two reports of the Select Committee on Sewage of Towns; the report of the Metropolitan Drainage Commission; the two reports of the Royal Sanitary Commission; the annual reports of the Registrar-General, and of the Medical Officer of the Privy Council; the yearly reports of the Local Government Board, and the nine reports of the two Rivers Pollution Commissions, together with those reports already named, have made the sanitary literature of England most complete and exhaustive.*

* This is not the place for a review of this valuable mass of information; but it is thought that it may be interesting briefly to mention the prominent features of the legislation that has made England the first of the nations in sanitary science.

The following list of the most important sanitary Acts will indicate how much has been done by Great Britain in this matter. The exact titles are not given in all cases:—

An Act to amend the Laws relating to Sewers, 1833.

An Act to amend the last-named Act, 1841.

Public Health Act, 1848.

An Act for further amending the Laws relating to Sewers, 1849.

An Act investing Local Boards of Health with certain powers, 1849.

An Act to amend the Public Health Act, 1851.

An Act to amend the Public Health Act, 1852.

An Act relating to Repayment of Loans under the Public Health Act, 1853.

An Act reappointing the General Board of Health, 1854.

An Act continuing in office the General Board of Health, 1855.

Diseases Prevention Act, 1855.

Nuisances Removal Act, 1855.

In 1848 the "Public Health Act" was passed, and, to secure its administration, the General Board of Health was appointed, to serve six years. The board was reconstructed in 1854; and in 1858, at the expiration of their term of service, their powers passed into the hands of the newly-appointed medical officer of the privy council, who is virtually a health minister of the English government. The "Local Government Act," to be construed in connection with the Public Health Act of 1848, was passed in the same year. In 1866 the "Sanitary Act" was passed. At the close of the session of 1872, a second "Public Health Act" was hurried through.

An Act transferring duties, etc., of the General Board of Health to the Privy Council, and appointing a medical officer of the Privy Council, 1858.

Local Government Act to amend the Public Health Act, 1858.

Nuisances Removal Amendment Act, 1860.

Local Government Amendment Act, 1861.

Drainage of Land Act, 1861.

Local Government Amendment Act, 1863.

Nuisances Removal Amendment Act, 1863.

The Metropolis Sewage and Essex Reclamation Act, 1865.

Sewage Utilization Act, 1865.

Nuisances Removal Amendment Act, 1866.

Metropolitan Sewage and Essex Reclamation Act, 1866.

The Sanitary Act, 1867.

Sanitary Amendment Act, 1868.

An Act authorizing Loans for Sanitary Purposes, 1869.

Sewage Utilization Act, 1870.

Hornsey Sewage Act, 1871.

Public Health Act, 1872, dividing England into urban and rural sanitary districts.

Public Health Act, 1875.

There have also been many Acts passed from time to time, with reference to special localities, and also on special subjects. Among them are the following:—

On Adulteration of Food, . . . 3	On Metropolis Management, . . . 3
Alkali Works, ... 2	Metropolis Water, ... 2
Artisans' and Laborers' Dwell-ings, ... 3	Quarantine, ... 1
Baths and Wash-houses, . . . 3	Registration of Deaths, . . 2
Burials, ... 9	Smoke Nuisance, ... 2
Cemeteries, ... 1	Thames Conservancy and Navigations (Pollution), . . 3
Common Lodging-houses, . . . 2	Towns Improvement, ... 4
Contagious Diseases, ... 2	Vaccination, ... 2
Laborers' Lodging-houses, . . . 1	Workshops Regulations, . . . 4
Main Drainage (London), . . . 4	

Beside those reports already mentioned, England has published over two hundred others on sanitary subjects, chiefly the results of special investigations.

This has been subjected to a great deal of adverse criticism, but it contains one important provision that it is worth while to notice. The Local Government Board had been formed in 1871, and by the new Act it became the central bureau, under which every sanitary authority was *obliged** to appoint a medical officer of health, who might be also the medical officer of the union in rural districts. As a result of this provision, no place in England or Wales is now without a sanitary officer; but they are often miserably underpaid, and elected by the local authorities of their own towns. They are, therefore, sometimes too much governed by local influences to be independent, efficient health officers; as they always must be in all countries under such conditions.†

The great objection to the Public Health Act of 1872 was that it was entirely permissive in its character as to the duties of health officers, and that something of a compulsory nature was needed. A step in such legislation has, however, been made in the "Artisans and Laborers' Dwelling Act," 1875, by which local authorities are not only allowed to tear down buildings unfit for use as dwellings, and to sell the land if the owner refuses to place proper buildings thereon, but under certain circumstances they can be compelled to do so by the central authority.

Finally, the "Public Health Act," 1875, consolidates twenty sanitary Acts into a single one of three hundred and forty-three sections, and makes the local officers of health responsible to the central government. Three commentaries on this Act have already appeared, edited by able lawyers.

THE SEWAGE-QUESTION IN ENGLAND.

Sewers have existed in England since the time of the Romans; but the first attempt at a sewerage system was made in London directly after the great fire of 1666. The old sewers had been badly constructed, and the introduction of the water-closet, about the beginning of the present century, only served to render still worse a soil which had already been seriously contaminated by soakage of fecal matters. The

* The "Contagious Diseases Act" *authorized* such appointments.

† See the Fifth Annual Report of the State Board of Health of Massachusetts under "Health of Towns," pp. 514 and 515.

evil became so great that, in London, an Act was passed forbidding the connection of water-closets with sewers; and cesspools came into use all over the city, contaminating the wells in all directions.

About 1815 an Act of parliament *allowed* water-closets* to be discharged into the sewers, and in 1847 another Act was passed *requiring* all cesspools and privies to be abolished, and the sewers to be used in their stead. It would be difficult to imagine the condition of filth then existing, as shown by Mr. Chadwick's report and those of the Health of Towns Commission. Open vaults, exposed to sun and rain, were often used for several contiguous houses. Cesspools and privies were made in cellars, and covered with dirt when full; and sewers, where they had been built at all, were too often simply badly-constructed receptacles for retaining filth, instead of discharging it.

The "Public Health Act," 1848, gave local authorities power to build sewers and discharge them into streams, wherever they saw fit. Then began, on a large scale, the pollution of the rivers of the country, which has since become so great an evil; for, by section xlix. of the same Act, all private dwellings, whether built before or after the passage of the Act, were required to have properly-constructed drains connected with the public sewers, provided there were any such within a distance of one hundred feet.

* Before 1847, the sewers of London were managed by eight separate corporations. To remedy the evils arising from this divided administration, and to devise a scheme for the permanent relief of the city, six commissions were at different times appointed; and finally, in 1856, the Metropolitan Board of Works was established, with full control of the matter. This board, after considering the various plans suggested, adopted that of Messrs. Hayward and Bazalgette for a system of intercepting sewers, high level, middle level and low level, with four pumping-stations, Thames embankment, and outlets respectively ten and fourteen miles below the city.

A great part of the session of Parliament of 1853 had been occupied in considering the scheme of "The Great London Drainage Company," composed of a number of private individuals, who guaranteed a large sum for carrying the sewage far below London, extracting its "valuable constituents," and selling them for manure. The company was to start with a capital of one million pounds, and assumed that there would be a great profit. Their plans were considered visionary, and were not adopted.

The metropolis, as defined by Act of parliament, covers an area of 117 square miles. [Report to the Metropolitan Board of Works by Messrs. Bidder, Hawksley and Bazalgette, London, 1858.]

By the "Nuisances Removal Act," 1855, provision was first made for enjoining individuals, towns and corporations against the pollution of streams. To provide for the full carrying-out of the requirements of the Act, section ix. contains a clause that "the local authorities *shall*" appoint or employ a sanitary inspector or inspectors. In 1858, the "Local Government Act" empowered local boards to make arrangements for the sale of sewage, or for its distribution over the land. Local authorities, too, were rendered liable to injunction for polluting streams.

At this time the rivers of England had, many of them, become so foul that a few towns had been forced into experimental works for precipitating the sewage, or utilizing it upon the land.* In 1860, the Sewage of Towns Commission, in their second report, said that the matter had become an "evil of national urgency, requiring the earliest and most serious attention, with a view to the application of remedial measures." . . .

"The Irwell, the Irk, and the Medlock, at Manchester, have long been notorious for offensiveness, both to sense of sight and smell." . . . "The bright stream above Middleton is made black and repulsive immediately below the town." . . . "The bright water of the Bradshaw Brook and reservoir soon become the color of ink." . . . "The discharge from some of the large towns [on the Rock] must, in the summer time, become a very dangerous nuisance." . . . "The water of the Mersey has become a black, offensive liquid." . . . "No description can give an idea of the fluid of the Medlock . . . At the time of our visit, a black, thick, noisome scum covered the surface of the river and canal, and bubbles of gas constantly burst up from below, although the weather was very cold. In summer this scum on the surface is said to be much extended, and at times of such consistency that birds walk over it. The stench is described as scarcely endurable."

With very few exceptions, the streams of the West Riding of Yorkshire ran with a liquid which had more the appearance of ink than of water. The Bradford Canal was so pol-

* One hundred and sixteen schemes were presented to the different commissions for purifying the Thames alone.

luted as to give off large quantities of inflammable gas, to which the boys used to set fire for amusement; the flames would sometimes reach six feet high, and run along the surface of the canal for many yards.*

Previous to the adoption of the Local Government Act, the Irwell River and the Greave and Clough brooks were so choked that in certain instances archways of bridges were blocked, sufficient room not being left for the storm-water, and parts of the neighboring town were consequently flooded. In 1870, the exceedingly offensive smell of one stream could be perceived at a distance of from one to two miles from its banks. . . . "It is no exaggeration to say that this brook renders the country, within two miles of its banks, uninhabitable, except under a penalty of so much discomfort as few would be prevailed upon to endure."† Another stream was so acidified by refuse from alkali-works, that iron boats could not be used in it. A gentleman wrote a letter to the Second Rivers Pollution Commission, using water from the Calder River instead of ink.

Even before public attention had been drawn so pointedly to such facts as these, it had happened that the first case of cholera in one of the epidemics occurred in a ship from a foreign port, anchored opposite the mouth of a sewer opening into the Thames. A war against sewers and water-closets began, and they were accused of causing diphtheria, typhoid fever, and almost every other disease, as if no other cause existed. Typhoid fever, especially, was said to be increased by the introduction of water-closets. It is a noteworthy fact, however, that many of the strongest opponents of the water-carriage system insisted on having water-closets in their own houses, and on using the sewers, which had by this time become necessities.

Undoubtedly bad ventilation, bad domestic arrangements, defective plumbing and polluted drinking-water from intermittent supplies, have given rise to a considerable amount of disease, and this has generally appeared about three years after the completion of works of water-supply and drainage,

* Third Report of the First Rivers Pollution Commission.

† First Report of the Second Rivers Pollution Commission.

because it requires about that time, under bad management, for filth to accumulate, and for the poison in the air and water to become sufficiently concentrated to cause illness. Hence has arisen the extraordinary statement that water-supplies and complete sewerage lower death-rates for three years, and then increase them.*

It has been claimed that the increase of diarrhœal diseases in England is due to the adoption of the water-carriage system; but a careful examination of the returns of the registrar-general shows the fact that, with the constantly-increasing density of population, such diseases have increased in Lancashire, where the old system of removing excrement by hand is still largely adhered to, but that they have remained stationary or decreased where water-closets have been largely introduced, the less favorable condition in the former case overbalancing the improvement in the latter.†

In Croydon, according to the high authority of Dr. Alfred Carpenter, typhoid fever has become a disease of the suburban part of the city, where there are no sewers. There have been two severe epidemics of typhoid fever in that city since the sewers were constructed. The first, twenty years ago, arose from pollution of the air, and was abated by the adoption of efficient sewer-ventilation. The second epidemic, that of 1875, has been already traced to an intermittent water-supply, polluted by sewage-emanations. Dr. Carpenter did not hesitate to predict this epidemic years ago, but the security of a few summers led the authorities to believe that there was no evil to remedy, and no remedy was applied.

* In Glasgow and Edinburgh, typhoid fever in the houses of the better class on high land is generally attributed to sewer-gases; but the sewers in these two cities are badly ventilated, and the water-closets are often adapted to old houses, and without any ventilation at all, in the proper sense of the word. In the poorer parts of these cities, where there are few water-closets, typhoid is rare, and typhus fever is common. One is inclined to think that the more virulent poison produces the severer disease (typhus), to the exclusion of the milder one (typhoid).

† The fact should not be overlooked that the high rates of mortality in Lancashire are probably, in a considerable measure, due to the character and condition of the laboring classes, and especially to the fact that women are so much employed in the factories that many of them are unable to nurse their children.

The known factors of the disease had been present for many years, and when the unknown factor was added, an alarming amount of disease and death was the result.*

Experience has fully shown that the dangers to health are least under the water-carriage system, if properly managed; and the common-sense of the community has declared it the most decent and the most convenient. In the report already quoted, the Sewage of Towns Commission say: "If one of two evils were unavoidable, it would be better that the rivers should be polluted than that the atmosphere in which we live should be subject to constant deterioration; but this is not really the question. Both evils may be avoided. But it is strikingly shown in this district [Lancashire] that, notwithstanding the purity of the air of the town is sacrificed by a retention of its fecal matter, the rivers are at the same time so polluted by the discharge of town-refuse of various kinds as to call imperatively for remedial measures."

In 1865, the idea had become quite prevalent that large fortunes were to be made both from the precipitated manure of sewage and by utilizing it on irrigation-farms, in spite of repeated statements of authoritative bodies to the contrary. The Metropolitan Sewage and Essex Reclamation Company was incorporated by special Act of parliament to raise a capital of over two million pounds to reclaim from the sea the enormous flats at the mouth of the Thames, and to utilize the sewage upon them. The enterprise failed.

In the next year, the advent of the cholera gave a new stimulus to the question, from the fact that the soil and wells were found to be so universally polluted by cesspools, etc. No distance from cesspool† to well that was practicable in a city was found to be safe. Eassie‡ found that in one place

* In September, 1875, the disease had entirely disappeared. On the 16th of that month the authorities gave another intermittent supply over a part of the district, and over that part typhoid fever again became prevalent. It subsided, and "the local board will not again make such a serious mistake."

† In England, at the present time, the slow poison from sewers, cesspools, half-buried and forgotten privies, &c., produces so characteristic a type in disease, that expert physicians do not fail to recognize it; and many unsuspected cesspools and leaky drains have in this way been unearthed.

‡ Sanitary Record, October 23, 1875.

cesspool-filth permeated through the soil for a distance of two hundred yards, and poisoned wells.*

According to Dr. Letheby, very many of such polluted wells in London "yielded cool, bright and clear waters." Other analysts say that they are "commonly clear." An official return in 1872 gives a list of polluted wells in the metropolis of London; and the Rivers Pollution Commission, in their sixth report (pp. 85 and 283), say that the samples from these wells consisted chiefly or entirely of the soakage from sewers and cesspools, and that some of them actually had a manure-value one hundred and fifty per cent. greater than that of average London sewage. One or two had a slight saline taste, piquant to some water-drinkers; but most of them were bright and palatable, and the pumps yielding them enjoyed, for the most part, a high reputation.†

In one epidemic of cholera, the water of the Broad Street pump, which enjoyed a wide reputation as a pleasant, sparkling beverage, although "horribly polluted" by a neighboring cesspool, is estimated to have caused 609 deaths. The Duke Street pump, in Dublin, had a similar history.

In the Sewage Utilization Act of 1865, we find this clause: "Nothing contained in this Act or any other Acts referred to therein (*i. e.*, all the sanitary Acts previously passed), shall authorize any sewer-authority to make a sewer so as to drain direct into any stream or water-course." By the same Acts, the powers of sewer authorities were extended as to the pollution of streams. Seventeen years had sufficed to reverse entirely the laws on the subject. In 1848, towns were urged to empty sewage freely into the most convenient water-courses.

* In France, attention was directed to this matter over forty years ago, and especially with regard to the pollution of wells from cemeteries. A law was passed prohibiting the opening of wells within one hundred meters¹ of any place of burial; but that distance was soon found insufficient for deep wells, which have larger drainage-areas than those near the surface, and which were found to be polluted, in some cases at a distance of two hundred meters. A well seventy-four meters deep, at Bondy, near Paris, was polluted by the contents of cesspools stored there.

† A celebrated horticulturist in Brighton, England, dilutes his manure until it has neither taste nor smell.

¹ As the metric system is used in several places in this paper, the reader is referred to the table of equivalents on page 18.

The Sewage Utilization Act of 1867 allowed authorities to purchase land, either in or out of their districts, or to lease it for seven years, for sewage-works. With the aid of all these Acts, and after many injunctions, the work of purifying the streams of England proceeded very slowly, until the Act of 1869 allowed towns to borrow of the general government money for sanitary improvements at a low rate of interest.

Even then, however, it was almost impossible for the court to enforce much vigorous action. In 1871, the Royal Sanitary Commissioners say (Second Report, vol. 2, p. 345): "These courts have proved incompetent to deal with the mischief and inefficient to stop the evil."

The latest legislation shows different results. In a recent case, "The Attorney-General *v.* the Mayor of Darlington," the defendants, who had been enjoined from polluting air and water by their sewage, petitioned to have the time for the completion of their works extended to June, 1876. The vice-chancellor held that the authorities had been dilatory, allowed them till March 1, 1876, to remove all causes of offence, and decided that they should pay the costs of the trial. The excuse that they could not get land he considered insufficient, as they might apply to parliament for a special Act to take land, if they could not get it under existing laws.

A few years ago earth-closets were accepted, by Act of parliament, as a substitute where water-closets had been required by previous laws.

There are no accurate returns of the towns which are making attempts to purify their sewage. In 1873 there were, according to a parliamentary paper, one hundred and twenty-eight that had done so by means of loans from the government alone.* As a rule, after injunctions have been served requiring towns "to purify their sewage according to the best known methods," the authorities have been apparently satisfied if any attempt is made, no matter how imperfect its results; and actual penalties have not, as yet, been inflicted on individuals, corporations or towns for polluting streams.

The Esk, and a few other streams, have been somewhat

* This is probably considerably more than half the total number. In 1858 twelve towns had adopted measures for the purification of sewage; in 1860, there were thirty.

purified from the refuse of manufactories, after repeated injunctions, and in a few cases from the fear of injunctions; but, generally speaking, there is not yet any decision reached as to whether the manufacturers themselves, or the towns within the limits of which they discharge their refuse, are to keep the rivers clean. The policy of the government has been gradually to educate the manufacturers into the knowledge that it is for their interest that the streams should be purified.

Considerable progress, however, has been made in purifying the refuse from dye-works and print-works, the alkaline refuse from the one neutralizing the acid from the other, and carrying down in the precipitate, as a mud, many of the impurities of both fluids. Solid materials, too, like ashes and cinders, are now kept out of the streams, in many cases; but manufacturers are generally obliged to have depositing reservoirs, in order to purify the water which they get for their own use, when they require to have it clean.

Several of the large cities in England get their water-supplies from sources polluted by sewage.* The stench from some of their rivers in summer is still considerable. Under such circumstances the greatest attention has been given to the subject. The first Rivers Pollution Commission was appointed in 1866, and the second in 1868. Their exhaustive investigations have extended over ten years. A Rivers Pollution bill was introduced in 1872, with the object of compelling the cleansing of the water-courses, but it has been modified many times, and has not yet been passed.

The Rivers Pollution bill of 1875 also failed to pass, but it fairly represents the mature opinion of England at the present time, and will probably be more successful at the next session of parliament. It provides that no liquid or solid sewage be passed into lakes, canals, streams or rivers, unless it be first purified by "the best practicable and available means"; that sanitary authorities provide sewers for manufacturers, the latter to pay any additional expense required for dealing with heated, filthy, noxious or polluting fluids discharged by them;

* Before a better water-supply had been furnished to Castleford and Birmingham, many of the inhabitants of those places were obliged to use the polluted waters of the Aire and the Tame for domestic purposes.

that no poisonous matters be discharged into the sewers until they be first rendered harmless; that the Local Government Board may *compel* local authorities to carry out the provisions of the Act; and, finally, that offences are to be restrained by summary order of the county court, defaulters to be fined £50 a day.

The English law does not state what are the "best practicable and available means" of purifying sewage. Undoubtedly, no universal rule can be made to apply to all cases. The impossibility of getting land in some cases, and the exorbitant rents demanded for it in others, have driven some towns to processes which did not find favor with them, but which can be carried out only on small areas.

No authoritative body,* so far as I have been able to learn, has declared itself as fully satisfied with any other process for the purification of sewage than that of irrigation.†

"Sewage-interception is always practicable. Where it can be applied fresh to the land, there is least nuisance, and least cost to the rate-payers. Where the solids are extracted by mechanical deposition, there is pecuniary loss in the operation, and running streams receiving the effluent water are still polluted, the pollution being greater as the volume in the stream is relatively small. No arrangements for treating

* Compare Mr. Chadwick's report in 1842; Mr. Austin's report in 1857; the reports of the Sewage of Towns Commission; the evidence before the select committee on the Sewage of Towns; the reports of the General Board of Health, of the Royal Sanitary Commission, of the Metropolitan Drainage Commission, of the two Rivers Pollution Commissions; and, finally, the reports of the Medical Officer of the Privy Council. In individual cases the officers of the Home Secretary have reported, after investigation, that "the best practical means of dealing with the sewage" had been used when other processes had been adopted. In these cases there was some special difficulty in the way, and a very liberal interpretation has always been given to the law.

† It has been stated by the opponents of irrigation that "parliamentary committees and royal commissions, that have been created for the express purpose of dealing with this important question, have approached the inquiry with a manifest bias in favor of some particular scheme, and with a preconceived opinion of the way in which the subject should be treated. They have, therefore, selected their witnesses and sifted the evidence so as to suit the particular objects in view." [The Sewage Question: from Dr. Letheby's "Notes and Chemical Analyses." London: 1872.] It can hardly be possible that such an opinion is at all general. It certainly would not find favor in this country.

sewage are satisfactory, except its direct application to the land for agricultural purposes."

This statement of the First Rivers Pollution Commission in 1867, may fairly be taken as the result of twenty-five years' experience in England; and the "official opinion," if the term may be used, has not changed since that time. They also recommended, "That after the lapse of a period to be allowed for the alteration of existing arrangements, it may be made unlawful for any sewage, unless the same has been passed over land so as to become purified, or for any injurious refuse from manufactures or agriculture, to be cast into the river Lea, or into any of its tributaries; and that persons offending in this respect be made liable to penalties to be recovered summarily."

The Sewage of Towns Commission (the Earl of Essex, Robert Rawlinson, J. Thomas Way and John Simon) has given the same opinion in their second report in these words: "It is matter of regret that so little progress has been made in the utilization of sewage in this way since the period of our previous report." They consider the most complete and beneficial method of disposing of sewage, where circumstances are favorable, to be its direct application to land in the liquid form. In their last report they say: "The right way to dispose of town-sewage is to apply it continuously to land; and it is only by such application that the pollution of rivers can be avoided."

SUBSTITUTES FOR THE WATER-CARRIAGE SYSTEM.

Many towns as well as individuals, with a view to avoiding the evils connected with sewers and water-closets, have adopted various substitutes, the more common of which, as used in England, will be briefly considered.

The more important of the substitutes for the water-closet system are,

1. Moule's Dry-Earth Closet.
2. The Charcoal-Closet.
3. The Goux System.
4. The Ashpit.

1. The earth-closet is tolerably familiar to us in this country ; but here and in England it is universally considered inferior to the water-closet in point of cleanliness and comfort, while scientific investigation thus far does not indicate that earth is any better as a disinfectant than water, if as good. Considering the trouble of providing sufficient earth (four pounds daily to each individual), the trouble and expense of artificially drying it, and the annoyance from frequent removal by hand of a large quantity of material which has only a trifling commercial value, the earth-closet has always given way as soon as water-closets have become obtainable. With careful supervision, however, they serve a very good purpose, and in country sick-rooms, especially if powdered charcoal be used instead of earth, are perhaps the best things attainable. Practically speaking, they do not often get attention and care enough. In New Orleans* they have become a great nuisance in the public schools. With constant care they serve an admirable purpose.

Dr. Buchanan, in a report on dry-earth closets, says, in the twelfth report of the Medical Officer of the Privy Council of England, p. 80 : "If about a pound and a half of suitable earth, *carefully dried*, be thrown over a dejection, all smell from it is forthwith removed ; and, if the same quantity be mixed with half a pint of urine, the latter is absorbed."

Even on this estimate, which is very low, of the amount of earth required by each individual, and assuming that four persons use one closet, every house would require, for each closet, about one ton of earth each year, making nearly 85,000 tons, or fifty acres of land about two feet deep, for a city of the size of Boston.

This earth must be dug, screened, dried, carted to the houses and removed again. The method is at least an expensive and troublesome one on a large scale.

2. The charcoal-closet is used by about twenty thousand workmen in the ship-yards on the Clyde, and in many of the public privies in Glasgow. It is open to many of the same objections as the earth-closet. If worked by automatic apparatus, it gets out of order easily. If the application of

* Report of the New Orleans Board of Health, 1875.

the absorbent is intrusted to each one after using the closet, or even to nurses and attendants, as in the fever hospital in Glasgow, this process is occasionally neglected, and a nuisance may result. The charcoal is removed and stored under cover until a considerable quantity has accumulated, when it is removed by a company who extract ammonia, etc., from it, and return it dry, free of charge, to be used again.

3. The Goux system, introduced from France, is used somewhat in a few towns in England. It consists in collecting the excrement in tubs lined with dry absorbents, such as dust, chaff, house-sweepings, etc. A feeble manure of slight value is obtained. In one of the towns in England where 3,120 of the Goux closets are in use, over a thousand tons of this manure have accumulated because, as the manager said, they will not allow the farmers to take it at one-fourth of its cost, which is all that could be got for it.

4. Ash-closets are used largely in Lancashire. In Manchester there are over 15,000 of them. The daily scavenging in that city is done at a cost of £10,000 a year, whereas all their privies, cesspools and ashpits might be abolished, and drains might be provided at a cost of only £60,000, of which the yearly interest would be £2,400 in place of the £10,000 now spent. This expensive and disagreeable method of removing the "filthy stuff, too poor for use * as manure," is adopted under the conviction that in this way their sewage may be kept inoffensive enough to be discharged into the river Irwell without purification; but the investigations of the Rivers Pollution Commission show conclusively that the sewage contains nearly as great a proportion of putrescible matter in this form as when collected by the water-closet system. The condensed table on the next page, from Hoffmann and Witt, shows this fact most clearly. The results are given in parts per 100,000.

Where, however, for any reasons, sewers are not to be had, this system of removal is very much to be preferred to cesspools, privies, etc.

* Where ashes are not largely mixed with the excrement, as at Rochdale, the sale produces quite a fair revenue.

COMPOSITION OF SEWAGE.		Average of 54 specimens from 18 cities and towns where water-closets are used.	Average of 37 specimens from 15 cities and towns where water-closets are not used.
Total of solid matters in solution,		72.200	82.400
Organic carbon,		4.696	4.181
Organic nitrogen,		2.205	1.975
Ammonia,		6.703	5.435
Nitrogen, as nitrates and nitrites,		.003	0.000
Total combined nitrogen,		7.728	6.451
Chlorine,		10.660	11.540
Suspended matter, .	{ Mineral,	24.180	17.810
	{ Organic,	20.510	21.300
	{ Total,	44.690	39.110

The proportion of putrescible organic matter in solution was greater from sewage in the water-closet towns, but that in suspension was greater in the others. Of course, the total quantity of refuse discharged by the sewers is less in the towns supplied with privies. The amount of sewage corresponding to 1,066 persons where water-closets are used, is the same as that from 1,154 under the other system.

EXPERIENCE IN FRANCE.

In France, sanitary measures have formed an important part of the *Code Napoléon* since the time of the First Empire. The scientific inquiries made in Paris, and the results as embodied in legislation, at the time when the French *grandeur* was at its height, were freely quoted in England when questions relating to public health began to attract attention there.

No general systems of sewerage in populous places had, as in England, sent the sewage of millions of people into the small streams. The manufactories of France are still largely such as do not use "gross material" to the same extent as is done in England, nor do they have so large an amount of refuse to dispose of. Even in the larger cities the *fosses d'aisance*, (cesspools) and *fosses mobiles*, (pails, tubs, barrels, etc., emptied by hand) are commonly used, while still ruder

appliances are common in the small towns and villages, so that comparatively little passes into the streams.

There are five laws (of 1669, 1672, 1777, 1782 and 1783) prohibiting, under penalty of punishments and fines, the obstruction of navigable rivers by dams and mills of certain kinds. At the same time, all persons are forbidden to cast into such rivers anything which tends to raise their beds, or to throw any filth of any kind on the banks. In the case of small, non-navigable streams, local *préfets* and *maires* are allowed to make and enforce such regulations* as the health of the community demand.

We have seen that formerly similar laws were enforced in England; but the enormous development of the manufacturing industry in that country, and the national sensitiveness as to the liberty of the subject, served in course of time to render them all dead-letters.

Much has been done in France towards the utilization of the refuse from manufactures, so that the rivers Vesle, Mollette and Montford, are now much purer than they were ten years ago. This result has been partly due to voluntary coöperation with the government on the part of the manufacturers, and partly to the coercive measures of the *Conseil d'hygiène et de salubrité*. Various plans for purifying the sewage have been tested, but the results of Prof. Moll's extensive experiments show that only irrigation is successful. In regard to the refuse fluids from starch-works, he says that, "before fermentation, they are inodorous and quite harmless for vegetables. If, on the contrary, they are kept in ditches for settlement, they soon stink and destroy all vegetation."†

In spite of the cesspool-system, and the necessarily offensive methods of emptying them, the sewage proper has already seriously polluted the streams in the neighborhood of Marseilles, Lyon, Rheims and Paris. In the latter two

* The fear of the approach of the cholera, in 1848, led to a decree creating in each district of France, a council of public health to be connected with a central council of the department. These boards have not accomplished much. Different branches of sanitary affairs are now under the Minister of Agriculture and Commerce, the Minister of the Interior, and the Minister of War and of the Navy. A strong effort is making for the creation of a Minister of Hygiene and Public Health.

† Translated by Edwin Chadwick, Esq. [Journal of the Society of Arts, September 17, 1875].

cities, expensive dredging is resorted to, in order to clear the Vesle and the Seine from sewage-deposits, and the stench from the two rivers is intensely disagreeable. At Clichy, when the larger intercepting sewer of Paris discharges, the stream is dark, offensive, and bubbling with gases that result from decomposition.* Nevertheless, the banks are lined with fishermen, who have "good luck" unless they get near the sewer-outlets, where the fish are too well fed to bite.†

The places are, then, comparatively few, where the pollution of the streams has become so serious as to make their purification a matter of immediate importance; but the matter has attracted the attention of scientific investigators for twenty years. By a series of experiments at the laboratory of the *École des Ponts et Chaussées* under MM. Belgrand and Léon Durand-Claye, the various precipitating processes were found to *clarify* the sewage; but the effluent fluids always contained a large part of the matters valuable as manure. No opinion was given in their report as to the value of the solid residue as manure. The laboratory experiments seemed rather favorable to precipitation, for no account was taken of the difficulty of getting rid of the precipitate, and the effluent was found valuable for irrigation.‡ One hundred thousand francs were, therefore, voted to M. Mille, who had already investigated and written upon the subject, and to M. Alfred Durand-Claye, to carry on experiments on a large scale at Clichy. A few acres of land were taken; irrigation was successful, but precipitation was only tolerably so. It was found that in practice the precipitation-processes were clumsy, offensive, costly and inefficient, that they *clarified* without *purifying*. Moreover, if the precipitate were carried more than a few miles, its value was found to be not sufficient to pay for cartage. The report was decidedly in favor of irrigation.

In 1849, it cost 9,000 francs to dredge sewage from the Seine. In 1869, the sum had increased to 100,000 francs. The river was rather sluggish, and complaints of offensive

* There are no extensive flats near Paris, as there are near London; and, there being no ebb tide to return the filth from the sewers, it is carried down to pollute the air and drinking-water of towns nearer the sea.

† It is *putrid* sewage or the refuse from certain manufactories which drives fish from the rivers.

‡ "Elles seraient très-favorables pour l'irrigation."

odors from it kept increasing. Finally, in 1868, 800,000 francs were appropriated for the works at Gennevilliers, a peninsula formed by a bend of the Seine opposite Paris. Two steam-pumps were located at Asnières, and iron conduits were built across the Seine to convey the sewage to the gravelly plain which it was proposed to irrigate. The city took a farm of twelve acres; and the result of the first year's cultivation by sewage was so astonishing that in the next July "farmers applied for twenty-four acres more; in August, for forty; and in September for sixty."* The profits of the farmers were great; for the soil was sandy and barren, and the sewage, which cost the city a large sum for its delivery, was given them for nothing. The experiment is still going on, although it was interrupted for a time by the war.†

In 1870 an official provisional injunction (*"sorte d'injonction"*) from the state increased the zeal of the city to purify the river, and renewed efforts were made to extend the area of irrigation. Six thousand cubic meters of sewage were used daily on eighty acres. A plan was approved which was to cost 10,000,000 francs; but the war broke out, and all operations were suspended. In 1872, a million francs were voted, and the work is continually extending.

As early as 1848, the increase of the woolen factories at Rheims had drawn attention to the great pollution of the river Vesle. Two intercepting sewers were built in 1852, conveying the sewage to precipitating-tanks, where it was clarified by simple subsidence. The process was kept up for five years, and was then abandoned because the precipitate met with scarcely any favor as a manure; "the pollution of the river continued," and the complaints against the city increased. The mayor appointed a commission, with Duchâteau at the head, who made an exhaustive report on the subject in 1870, after making many experiments with sewage on a small scale. Their experience was derived from England, and they decided to try the two methods (irrigation and precipitation) in use.

* One hundred and eighty acres were cultivated in 1874, and about the same number in 1875; forty thousand cubic meters of sewage being delivered on the farm daily, of which a considerable quantity was wasted.

† The bridge carrying the main conduits was blown up. Later it was the scene of an engagement between the Commune and the army of Versailles.

there. The river had become extremely filthy. Its greatest flow was eight cubic meters a second, and in summer only six hundred or even two hundred decimeters. It received nineteen thousand cubic meters of sewage daily, or three hundred to each one thousand inhabitants.* The river contained, in itself, only twice as much water as there was sewage flowing into it. The daily discharge of sewage contained thirty thousand kilograms of impurities in suspension and in solution.

The "lime process" was tried and found inefficient, because, although it precipitated the solids, its action on the soluble organic matter, like that of all other chemical processes, was almost nothing. The ammonia was set free by the stronger alkali, and lost; so that people complained of the bad smell from the works as much as ever before.

Similar practical difficulties were encountered in testing the other precipitating processes, and none gave results "worthy the attention of the commission," except a mixture of lime with a ferruginous clay and sulphate of iron. The manure produced cost 176,000 francs a year, or eight francs a ton, including transportation of six miles. It could be sold only at great loss, as each ton (nine hundred kilograms,) contained two hundred kilograms of worthless mineral matter, and three hundred and fifty to seven hundred kilograms of water. To obtain an idea of its value as compared with common manure, which was much cheaper, three lots of land of equal size, were cultivated for two years, with the following results in crops raised during the two seasons:—

CROPS RAISED.		Lot 1—With stable-manure, weight in kilograms.	Lot 2—With sewage-precipitate, weight in kilograms.	Lot 3—Without any fertilizer, weight in kilograms.
First year, beets, ...		44,400	37,200	25,000
Second year, wheat, {	Straw, ...	6,080	4,900	2,740
	Grain, ...	1,860	1,540	1,175

* In Paris the proportion is only one-half as great.

Fifty cubic meters were used upon each acre. Irrigation was decided to be the least expensive, and the only satisfactory method, and has been adopted.*

The sewage of Versailles and of St. Germain will probably be utilized, as complaints are loud in regard to the condition of the streams into which they drain. Imperfect irrigation is carried on at Carcassonne, Cambrai, Aix and Chambery. Many of the manufacturers in the north of France partially purify their sewage, or irrigate with it.

The precipitating processes are not used by cities or towns.

EXPERIENCE IN GERMANY.

There are no general laws in Germany for the supervision of factories, nor any laws forbidding the discharge of sewage into water-courses. The Act of 1843, of Prussia, prohibits manufacturers from casting into streams water which had been used for dyeing, fulling, tanning, and similar processes, if annoyance be caused thereby to the public, or their supply of pure water endangered. The law of 1846, of the same country, requires owners of works to remove from the sewage any ingredients injurious to the culture of any meadowlands over which they may flow. The interpretation and enforcement of these two Acts rest with the police of the various cities and towns.

Until ten years ago, Hamburg was the only German city which had a sewerage-system, and water-closets in a large number of its houses. The other cities were all more or less filthy. Throughout the Empire, the use of cesspools and tubs was universal. Varrentrapp stated, in 1868, that it was offensive, to both eyes and nose, to enter the majority of German houses in the warm weather. The few sewers which existed were, many of them, so choked with filth, that it was often difficult to ascertain even of what their bottoms were made. In spite of all this, some of the rivers were very filthy, although none of them, except the Spree and a few others, had approached the condition of some of the English rivers.

* Rapport sur les Eaux d'Égout de Reims par M. Alfred Durand-Claye, ingénieur des ponts et chaussées. [Bulletin Mensuel de la Société des Agriculteurs de France, 1er Juillet, 1873.]

Berlin, a city now of nearly a million inhabitants, in 1861 had only 1,584 houses supplied with water-closets, and the number was not quite trebled in the next four years. The city was so badly drained, that the authorities had been at work, since 1828, trying to devise means for improving it. Various projects were proposed; but some were too costly, and others were insufficient.

Scientific men, with Pettenkofer at their head, opposed sewers, because the only ones with which they were familiar were badly constructed, allowing the sewage to escape freely, and to contaminate the soil. This was considered an evil to be avoided at any cost, in view of the theory that typhoid fever and cholera were directly dependent on low levels of ground-water, and organic decomposition going on there. By digging down to the sides of badly-constructed sewers, Pettenkofer found the soil moist and foul-smelling; and Feichtinger found large quantities of organic matter in such soil. In his report on the sewerage of Basel, in 1869, Pettenkofer opposed the introduction of water-closets.* Even granting that sewers were necessary, he thought that by keeping out of them the contents of water-closets, just so much more sewage could be kept from getting through into the soil. To his surprise, however, he found that in Rugby, with water-closets, a liter of sewage contained 151 milligrams of organic matter, while in Munich, without water-closets, it contained much more; namely, 189 milligrams. It appeared, too, that although it was forbidden by law to empty privies, etc., into the sewers, it was done so much, under cover of darkness, that night-sewage contained 37 per cent. more of soluble organic matter than that of the day-time. The chlorine and potash, especially, were increased.

In 1868, Varrentrapp published his exhaustive treatise on the drainage and sewerage of cities, completely refuting the theory that sewers must pollute the soil, and showing that

* Sewers, he said, are as bad as cesspools for contaminating the air and soil, and the cesspool-system, well ventilated, is as efficient as sewers in maintaining the purity of the air, ground, and water near houses. (*Laft, Boden und Wasser des Hauses ebenso rein zu erhalten mag wie das Schemm-system.*) Lindley, the distinguished engineer of the works at Hamburg and Frankfort, says that cesspools cannot be made to remain absolutely water-tight, a statement which experience has confirmed in Paris.

twenty-five years had failed to produce any such effect in Hamburg, an observation which was afterwards verified by Virchow and Pettenkofer. Varrentrapp argued that, on purely sanitary grounds, filth should be speedily and thoroughly removed, and that such an end could be accomplished only by water-closets. His practical statements were found so convincing, that the cities of Germany are fast adopting the methods which have proved so successful at Hamburg. The inland cities, generally speaking, are preparing to dispose of their sewage by irrigation, either at once, or when the increasing pollution of the rivers may demand it.

At Dantzic, the English example has been followed, by the advice of the distinguished engineer, Wiebe; and irrigation has been adopted, after some successful experiments in sewage-farming, at one of the orphan asylums.

In Munich, Pettenkofer has continued his researches on the pollution of the soil, and has finally shown, as already proved by Lindley, that well-built sewers do not allow soluble organic matter to escape into the ground to any serious extent, although they act as drains in relieving the soil of its moisture.

Dr. Wolfhügel has also proved this fact, by careful analysis of the soil in different places, as is shown in the following table:—

Table showing the comparative pollution of the soil from sewers, cesspools, and privy-vaults, as given by Dr. Med. Gustav Wolfhügel.

[Results expressed in kilograms to the cubic meter of earth.]

COMPOSITION OF EARTH.		Normal earth.	Average of earth under eight sewers.	Average of earth under eight cesspools.	Earth 4 1-2 meters from a privy-vault.
Depth in meters at which analyses were made, .		3.7	*	2.4†	2.3
Soluble constituents, .	Residue on evaporation, .	.211	.217	.603	4.710
	Loss on ignition, .	.052	.091	.185	1.500
	Organic substances, .	.118	.093	1.257	2.230
	Chlorine, ...	.010	.021	.110	.330
Insoluble, .	Nitric acid, ...	.012	.018	.019	.460
	Loss on ignition, . .	1.504	3.356	5.461	39.772
	Nitrogen, ...	.014	.055	.060	.956

* Directly under the sewers.

† Directly under the cesspools.

By digging underneath well-built sewers, Dr. Wolfhügel showed experimentally to a large number of experts that the soil was not appreciably affected by the sewage.

In Berlin, a scientific commission was appointed in 1862, and made exhaustive experiments, continued through many years. They proved by scientific analysis and by induction, what had long before been learned in England by practical experience:—

1. That with cesspools and privies, the soil and well water become dangerously polluted.

2. That sewers need not pollute the soil.

3. That streams become so foul when used as receptacles for sewage, that measures must be taken for their purification.

4. That the only practicable means of purifying sewage is by irrigation.

They have, therefore, adopted a sewerage-system which is to be completed in 1883, and which provides for purification of the sewage by irrigation.

The Berlin commission experimented with many deodorizers,* all of which failed to prove efficient at reasonable cost. Of the precipitating systems, they tried, during several years, Suvern's (lime, tar, and chloride of magnesium) and Lenk's (alumina, soda, and chloride of zinc or iron) as promising the best of them all. They say of both that more than one-half of the soluble organic matter passed off with the effluent; that the living organisms, *bacteria*, etc., were not killed, and that the effluent was unfit to run into rivers. Of Suvern's process, they say that the "manure" produced was not of sufficient value to pay for cartage and labor;† while by Lenk's system a precipitate was formed which was worth less still, land manured with it producing smaller crops to the acre than unmanured land. Both processes clarified the sewage, the latter less quickly and completely.

* As was done by the French experimenters also; the latter selected only three, which were thought to show a reasonable prospect of success.

† In their general report they say that its value was "gleich null,"—"absolutely nothing."

EXPERIENCE IN HOLLAND.

The Netherlands, as is well known, are reclaimed from the sea, being surrounded and protected by enormous dikes, upon which the country depends for security against inundations. The level of the canals in Amsterdam is thirty centimeters below half-tide mark. Many of the cultivated fields throughout the country are covered with water during the winter months, and are kept dry in the summer by means of wind-pumps, which raise the contents of the ditches at the sides of the fields to canals, conducting them finally to the sea.

It is easy to see that the difficulties of drainage and sewerage are great, and that an abundant supply of pure water for domestic purposes is almost an impossibility. Many of the houses in the cities have common privies, discharging by straight, or nearly straight, tubes into the canals. Among the wealthy class there are a few water-closets and cesspools. The very poor have no accommodations whatever, and throw into the stagnant canals the refuse which does not escape by surface-drainage, or into the sewers at the street-openings. In Amsterdam, the canals comprise about one-fifth of the area of the city, forming ninety islands connected by nearly three hundred bridges.

Under such circumstances, the government, finding that there were so many objections to all other systems of sewerage, decided to give to the pneumatic system a fair trial. Schmick had proposed such a method for Frankfort, and other similar systems had been used to a small extent in a few of the cities of Europe.* Capt. Liernur alone, however, has brought it to any degree of perfection, and he states that it is found completed, according to his plans, only in Holland.† Plans were accepted for Leyden in 1870, and for

* It is said that Capt. Liernur got his idea from the rude pneumatic system in use at Milan, where a vacuum is got by first filling the tanks with water and then exhausting them. The water is carted about in ox-carts.

† It was first introduced into Prague in 1868, for some military barracks; later, into an insane asylum at Hanau. In answer to the statement of the Berlin Commission that in these two places the system had proved offensive, and so unsatisfactory as not to be extended, Capt. Liernur stated that the first attempts had been improved upon, and that in Holland he had overcome the difficulties which had proved so troublesome at Prague and Hanau. A commission at the Hague recommended Liernur's system for that city in

Amsterdam a few months later. The works were completed in 1871.

In Leyden, a city of 40,000 inhabitants, 1,200 people in the poorest quarter have their houses furnished with Liernur's system. That it is very much better than the previous arrangement of throwing filth into the canals by hand, is universally agreed. The authorities, however, as in Prague, apparently do not consider that the gain is in proportion to the great expense incurred, for no extension of the scheme has been agreed upon.

In Amsterdam, the odors from the canals have been for years extremely offensive.* They are all open sewers, with no current, and foul gases are constantly bubbling up during the summer. During winter the offence is less, and arises chiefly from the distribution of so much filth upon the ice. Naturally, the authorities were willing to try any system which promised any solution of their difficulty. They adopted the Liernur system in one of the poorest quarters of the city in 1870. On the 10th of April, 1872, Mayor den Tex and the aldermen decided upon its compulsory adoption in seven other small districts. At the present time, it has been introduced for a population of 6,000, or one-fiftieth of the whole city. Mayor den Tex, and the present Master of Public Works, state that it has given entire satisfaction in the poorer parts of the city, where there was absolutely no accommodation before, and where the closets connected with it are out of doors. They state, also, that its first cost renders it doubtful whether it will be extended

1867, but it has never been introduced there. It has had a similar fate lately in Rotterdam. In St. Petersburg, Capt. Liernur is making an experimental introduction of his method, with the understanding that the city is not to bear any of the expense; and that no extension is to be made unless the system proves satisfactory. Capt. Liernur is preparing plans which he hopes may be accepted for Geta and Naples. He has an agent in London, but none of the cities or towns of England have accepted the system. It has not met with approval in that country.

* The deposits in these canals, which are about four feet deep, are dredged out twice a year, and sold for a small price as manure; otherwise, navigation would be very much impeded. Since the completion of the great North Sea Canal, the canals of the city have been flooded every night by opening the gates and allowing the water to flow through from the North Sea to the branch of the Zuider-Zee, on which the city is situated.

even there; and that among the better classes the system is considered inferior to water-closets and cesspools.

*Description of the System.**

The following description is taken from a pamphlet published by Mr. Scott:—†

“In a building, in any convenient part of the town, is placed a steam-engine, which drives an air-pump, so as to maintain about three-fourths vacuum in certain cast-iron hermetically-closed reservoirs sunk below the floor.

“From these reservoirs central pipes radiate in all directions, following the main streets. On these central pipes are laid, from distance to distance, street reservoirs sunk below the pavement.

“From the street reservoirs, up and down the street, are main pipes, communicating by short branch pipes with the closets of each house.

“All the junctions of pipes with reservoirs are furnished with cocks so that they can be shut off or turned on at pleasure, like water-mains, and are got at by cock-boxes, and turned by keys in the ordinary way.

“The vacuum created in the central building reservoirs can thus be communicated to any given street reservoir, so as to furnish the motive-power by which, when the connections with the houses are opened, all the closets are simultaneously emptied.

“When their contents reach the central reservoir, they are in like manner forced through the central tubes to the reservoirs under the central building, and thence transferred by means of vacuum-power to hermetically-closed tanks above the floor of the building. From these retorts the matter is decanted in a fluid form in barrels, for immediate transport to the country, by means of hermetically-closed apparatus.

“During the construction of this system, and before connections are made with the central building, a locomotive engine empties the different street reservoirs, and the closets connected therewith, by means of a hose from the tender to the reservoir.

* For full description see *Die pneumatische Canalisation in der Praxis* von Capitain Liernur, Frankfurt, A. M., 1870; also articles by Mr. Adam Scott, C. E., Capt. Liernur's agent in London, in the *Sanitary Record*, Nov. 21, 1874; *Public Health*, Oct. 16, Nov. 2, and Dec. 16, 1874; the *Journal of the Society of Arts*, vol. xxiii., London, 1875; also various papers in the *Deutsche Vierteljahrsschrift für öffentliche Gesundheitspflege*, and the *Correspondenz-Blatt des Niederrheinischen Vereins für öffentliche Gesundheitspflege*.

† Brief Description of Liernur's Pneumatic Sewerage-System. London.

"Closets of the simplest possible character are all that are required, and no water whatever is needed. The funnel is made double, the space between the two communicating by a pipe with the outside air.

"The excrement falls into a sort of hydraulic trap, capable of holding the fecal products of but one person, and compelling thus what it held before to fall into a larger trap of four times greater capacity. This latter discharges in the branch tube which is connected with the main tube, and empties into the street reservoir.

"The branch tubes from the houses are laid with a succession of grades, not less than one in ten, rising at every twenty feet by a short siphon-tube, two feet high, to the beginning of a new grade, until it falls into the main tube. It is by means of these continually repeated short bends that the removal of the contents of so many privies, by turning only one cock on a main pipe, is possible, whether or not any are empty on account of the house being uninhabited. The fecal mass itself practically forms the required temporary closure from the main pipe, allowing through its inertia all the branch pipes to be simultaneously and equally acted upon under all circumstances. All metal valves formerly employed for this purpose, and likely to get out of order, are now done away with.

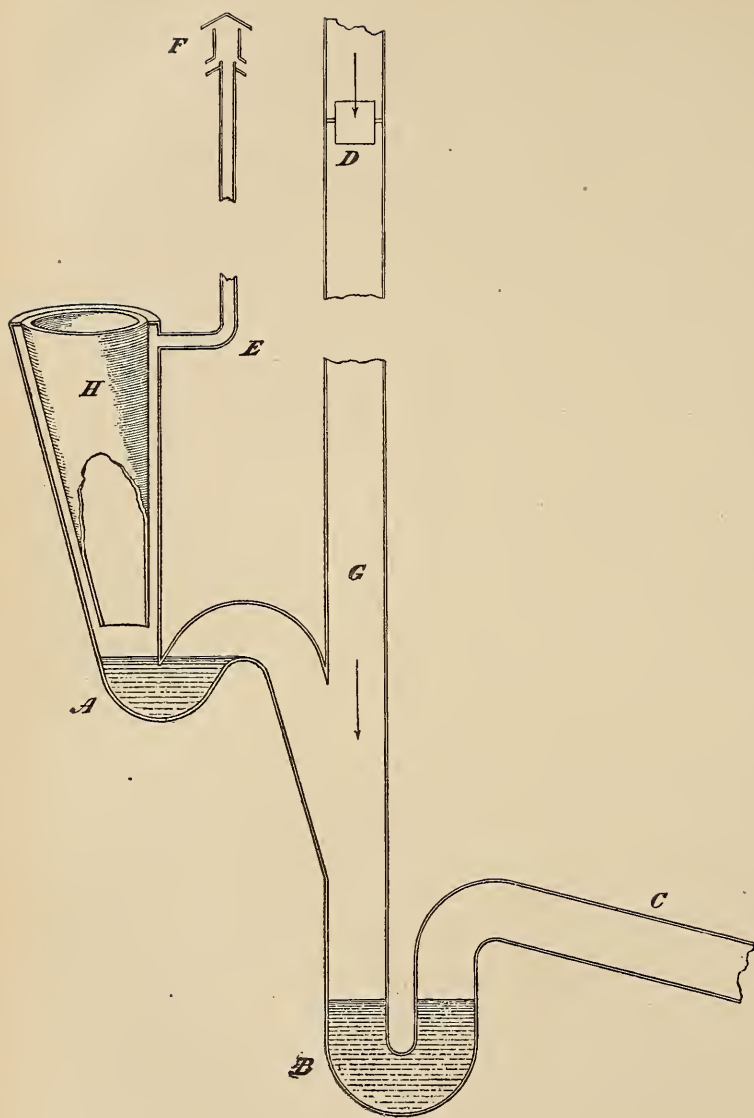
"The main pipes, into which the branch pipes discharge, are laid with a fall of one in seventy-five, without any break until near the lower end, when they are suddenly bent upwards by a siphon-pipe, so as to reach the upper part of the reservoir. On the upper part of the siphon is placed the cock which connects or disconnects the main tube with the reservoir.

"The central tubes which lead directly from the reservoirs to the central building reservoirs, communicate with the lower part of the former, by means of short pipes, and proceed in grades of one in a hundred, broken every hundred meters by a siphon rise."

Capt. Liernur's calculations of cost,* although very high, provide for the removal of excrement alone. With his system, there must be also sewers for rain-water, street-drainage, slops, etc. He would have separate pipes, too, for the drainage of the soil.

The working of the apparatus is generally satisfactory, and the four years of experience have not shown any great likelihood of its getting out of repair. Capt. Liernur states that the insides of the pipes become coated with a moist "schleim-artig" (slimy) substance; the various bends in the pipes, too,

* Five million dollars, for instance, for the city of Berlin.



THE "LIERNUR SYSTEM."

(General Plan of House Arrangements.)

must serve as pockets for collecting a small amount of putrescible organic matter; but the ingenious inventor of the system naïvely says that the trap of fecal matter prevents sewer-gases from getting into the houses, as if there were not offensive gases from the trap itself.

A simple sketch by Capt. Liernur, not drawn to scale, will help to give an idea of that part of this system which is connected immediately with the houses.

H represents the seat, surrounded by a narrow, open space which communicates with the outer air by the pipe E and the ventilator F. This ventilating-pipe is for the purpose of keeping a continuous upward current, and of preventing the escape into houses of any odors from the fecal trap A, which, it is unnecessary to say, is not accomplished. The excrement at A falls by gravity-overflow into B, whence it is removed by causing a vacuum in the tank to which C leads. During the process of emptying, the external air is driven down D G, forcing the excrement before it. The charcoal-box D is supposed to be alternately fouled and purified by sewer-gases passing up, and pure air going down through it! It is Capt. Liernur's theory that A remains a constant trap of excrement, even during the process of emptying.

By the politeness of Mr. Bergsma, Secretary of the Board of Works of Amsterdam, a friend of the system, I was able to see it in actual operation.

The emptying of the tanks was complete, rapid, and, as far as I could see, successful. There was no trace of odor. In the central building, where the matter was transferred to barrels, and in its immediate vicinity, the stench was very great.

In the houses of the poorest class, where one house is used by several families, they become soiled, and in some cases filled to overflowing, before any one takes care of them. They become clogged occasionally by coffee-grounds, ashes, etc., which will find their way into them. They are not as offensive as the midden or privy, still to be found in many large cities. They are in all cases out of doors, and the people who use them prefer them to the arrangements which existed before their introduction.

In a few houses of the middle class, where they are in the

yards, a few rods from the houses, they were scrupulously clean, received frequent washing, and were not offensive.

In a primary school-house, where the closets were separated by only a narrow passage-way from the class-rooms, they were frequently washed, and, although there was a slight disagreeable odor, there was nothing really offensive at the time of my visit.* It is undoubtedly true, as the teacher said, that the closets are much more satisfactory than anything which they had ever had before.

In the houses of the better class there is so much complaint of the bad odor from the closets, that they get rid of it as best they can by flushing, with a sudden dash of a large quantity of water, after each use of the seat. Occasionally they become entirely clogged, when the odors are simply insupportable. Mr. Dyck, a resident of Amsterdam, who has also a farm in the country, states that twice in one year this intolerable stench drove him and his family entirely out of his house until the obstructions could be removed.†

Capt. Liernur proposes to meet this difficulty by automatic water-closets, using only one liter of water at each time of use; but they have not been put to the test of practice, and so small a quantity can be of no more service there than in our ordinary hopper-closets.

A part of the original plan was to sell the excrement at a remunerative price; but people of the neater class cannot be prevented from flushing their closets liberally, and the contents of the reservoirs contain so large a proportion of water as to have the general appearance of ordinary sewage, except in color. Dr. Amersfordt made a contract with the city to take the whole of it, to be delivered on his farm at 11½ cents (U. S. currency) for each one hundred liters. The contract expired January 1, 1875, and has not been renewed, for two reasons. Dr. Amersfordt states that the distribution of

* In his official report to the Oberbürgermeister of Cologne, Stadtbaumeister Becker states that he found in these rooms an offensive odor (übler Geruch) [*Correspondenz-blatt des Niederrheinischen Vereins für öff. Gesundheitspflege*, I., 131].

† *Deutsche Vierteljahrschrift für öffentliche Gesundheitspflege*, VII. 1, p. 24.

The closets have "ventilators," i. e., pipes running up to the tops of the houses; but at the time of my visit I found none which had any influence upon a lighted match placed at their lower apertures.

largely-diluted manure from barrels is costly and difficult; also that, when delivered to him in the winter, it is often frozen in the barrels. It is now sold for $16\frac{3}{4}$ cents (U. S. currency), delivered by boats on the farms, during the summer only. In winter it is carted down below the city and thrown into the harbor, as it cannot be sold.

At Dordrecht, this system is in process of introduction for 128 houses, with a population of 800 people, and Capt. Liernur is making preparations to make poudrette on a large scale, from which he hopes to obtain a considerable revenue. It should be remembered that a similar experiment failed in Amsterdam twenty years ago; that the Paris poudrette sold for one-twentieth of the value placed upon it by the chemists; and that an English company has become bankrupt in attempting to pay two francs a cubic meter for the contents of the cesspools in Paris, leaving several hundred thousand cubic meters at Bondy, of which the authorities would be glad to rid themselves.

The "Liernur System" has been very widely proclaimed; but, as has been seen, it has not yet met with much favor, even in Holland, to judge by the number of people now using it.

By the courtesy of Hon. Frederick Schütz, United States Consul at Rotterdam, I am enabled to publish the following valuable documents (translated), which he kindly procured and sent to the Board:—

DORDRECHT, January 20, 1876.

To the United States Consul at Rotterdam.

Complying with the request contained in your letter, dated January 10, I have the honor, in reply to the questions therein mentioned, to communicate the following:—

The Liernur system, including a central station for engines, etc., is applied in this community upon an area of about 17,300 meters, with about 800 inhabitants, distributed over 128 houses, containing 117 privies. There is a provisional project for the extension of the system, to include about 176,000 meters, with 8,640 inhabitants, in 1,273 houses, with 1,160 privies. Further, the Liernur system is to be applied to a number of separate houses, where the house-pipes unite in a reservoir, which is emptied once or twice a week by means of a movable steam air-pump (locomobile), or, in default thereof, with one worked by hand (hand-air-pump-cart). In the same man-

ner it is managed in a school, with 160 children, and this will also be done with the hospital now in construction. On building new houses, the owner is given choice between the Liernur system and the cesspool systems, the latter having obtained a large extension in the last two years. Only in the suburbs immediately on the edge of the river and its open branches are common privies allowed to discharge until further order. The extension of the above-mentioned provisional project is delayed, awaiting the results of the poudrette preparations, with regard to which it is thought that sufficient information will be obtained within a few months. This execution will only be done gradually, and will thus be divided over a great number of years. If the system remains satisfactory during that period, and it is especially evident that the preparation of the poudrette is giving favorable results, then it may be most probable that the remaining parts of the city will be supplied therewith. The experiment of the system is going on gradually, and, at all events, the practical possibility thereof is sufficiently proved; although the expenses for beginning and the difficulties connected with it, in some wards, are considerable.

With regard to the profit on the capital invested in the system, nothing can as yet be stated with certainty, as this community finds itself still too undecided to do so definitely. While the experiment is being carried on, we await more definite regulations from the person who has the contract for cleansing the city.

The Mayor of Dordrecht,

[Signed]

D. W. HOOP.

LEIDEN, January 21, 1876.

To the United States Consul at Rotterdam.

In reply to your letter, dated January 9, by which information is requested regarding the operations of the Liernur system at this city, I have the honor to remit a printed report made by the master of works in 1873; while for further explanation, the following may be communicated: The ward or neighborhood upon which the Liernur system is applied has a surface of about 14,000 meters, with about 1,200 inhabitants, while the surface of the whole community amounts to 1,989,340 meters, with 40,000 inhabitants. The system has been in operation since February, 1872, and no complaints of any importance have been received from the tenants, neither from the proprietors of the houses nor from the directors of public institutions; while in general it may be said that in the general management not a single difficulty of any moment has presented itself. Meanwhile there exists for the present no intention to extend the system in other parts of the city, because of the considerable expense involved

in so doing. The produce of fecal material, however, has thus far covered the expenses of the experiment. From the statement of the master of works, it appears that the produce of the last nine months was, at $f0.30$ (12 cents, U. S. currency) per 100 hectoliters; or, in all, $f1,130.70$ (\$452.28, gold). For 1873 the produce was $f1,496.16$ (\$598.46 $\frac{2}{5}$, gold); for 1874, at $f0.40$, per 100 hectoliters, it amounted to $f1,836.23\frac{1}{2}$ (\$734.49 $\frac{2}{5}$, gold). After the termination of this contract, a new contract could not be made for more than ten cents, Dutch currency, or four cents, gold, per 100 hectoliters, consequently the produce per year could be estimated at an amount of only $f450$ (\$180, gold). Against this, the expenses amounted, in 1872, to $f3,995.04$ (\$1,598.01 $\frac{2}{5}$, gold); in 1873, $f2,178.26\frac{1}{2}$ (\$871.30 $\frac{2}{5}$, gold); in 1874, $f3,206.18$ (\$1,282.47 $\frac{1}{5}$, gold). The expenses for 1875 are estimated at $f2,000$ (\$800, gold); and for 1876, on $f1,760$ (\$704, gold). Although the experiment with the Liernur system, taken in this city from a technical point of view, may be said to have entirely succeeded, the financial results, however, must become considerably more favorable before an extension of the system will be resolved upon.

The Mayor of Leiden,

[Signed]

V d BRANNDEN.

LEIDEN, April 1, 1873.

To the Magistrate, President of the Commission of Manufacturing Industry.

An application of the Liernur system was made upon a long row of small tenement-houses in the old Hoof Street, the rear bordering upon the Achter-of-Binnenvest Canal, which had been filled up in connection with the construction of sewers, and where thirty-five privies formerly discharged, free and uncovered; further, upon both sides of the Yarn Market and St. James Canal, with the largest part of the Fame Alley. The discharge-pipes of the privies from all the tenements in these streets came together in the two main sewers of the Yarn Market and St. James Canal, which were running by two outlets into the above-named rear canal; so that this canal, being without a direct stream running through it, and also narrow and shallow, without fence or walls, formed, literally, an open sewer. This condition, which repeatedly proved to be unbearable, especially at a breaking out of contagious diseases, together with the then pending projects for an improvement thereof, gave ample reason for making a trial of the Liernur system. The number of buildings in the above-mentioned ward to be supplied with the pipes, including the stables, coach-houses, working places, and the Roman Catholic asylum for orphans and aged people on the St. James

Canal, in which 177 orphans and old people were provided for, amounted to 126, with full 977 inhabitants, to whom are to be added 400 children in an infant school on the Yarn Market. Leaving out the half of this number of children as being present only during the day, the population can be estimated at 1,200. The number of privies in the tenements and establishments is 166. Among those, twenty-six are on upper floors. The old main sewers, privy branches and spouts were allowed to remain for the purpose of carrying off rain, wash, and factory water, in connection with a new constructed water-channel in the (filled up) rear canal. The expenses for arranging the pipes with appurtenances, placing reservoirs with ground-work, attaching the privy funnels, and repairing mutilated floors, ceilings, walls, etc., the procuring of a steam-engine (locomobile), conveying wagon or tender, with tubes, cranes and many other necessary appliances amounted to £26,816 88½ (\$10,726 75½). According to a specified estimate by

Messrs. Liernur and De Bruyn-kops, the work was to cost . . .	22,000 00	(8,800 00)
So that beyond the estimate there was still demanded . . .	<u>f4,816 88½</u>	<u>(\$1,926 75⅔)</u>

This considerable excess beyond the estimate was especially due to an account of Liernur & De Bruyn-kops, for engineers' salaries, travelling expenses, expenses of an engineer's overseer, in charge of the arrangement, and extra fees of a machinist for levelling. All this, with one thing and another, was not taken into account in the estimate; it is also due to a great many special expenses, which the contractors could not foresee, and which demanded some indemnity. Also, there are to be taken into consideration the expenses of experimenting during the year 1871, which had to be made from pipe to pipe, as the pipes were laid, of which no separate account could be kept. The expenses of experimenting during the year 1872, in which year a regular collecting and transportation of the fecal material took place, amounted to the sum of f3,995 04 (\$1,598 01 $\frac{2}{3}$). No contract for the sale of this fecal

material, upon fairly reasonable terms, could be made until April 1. The sum received during the last nine months of 1872, for 3,790 hectoliters at 30c. (12c.

U. S. currency, gold) per 100 hectoli-		
ters, was	1,130 70	(452 28)

Consequently, a deficit of \$2,864 34 (\$1,145 73 $\frac{2}{5}$)

To this is to be added the expense of
transporting the engine and tender with
horses to a distant pumping-station, .

f1,262 50 (\$505 00)

f1,601 84 (\$640 73 $\frac{2}{5}$)

Could the contract have been made for
the whole year, on the same terms, the
deficit would have been decreased by .

376 90 (\$150 76)

f1,224 94 (\$489 97 $\frac{2}{5}$)

The great expenses for transporting the engine by horses, and the damages caused to it by the jolting and shocking in moving, led the authorities to decide upon an experiment with a stationary engine. During the last months of the year a new building was erected for the above purpose, in a suitable location; all necessary appliances were provided, and for this there was made an appropriation to the amount of f7,200 00 (\$2,880 00)

Adding to this the first expenditure, ... 26,816 88 $\frac{1}{2}$ (10,726 75 $\frac{2}{5}$)

The total expense amounts to f34,016 88 $\frac{1}{2}$ (\$13,606 75 $\frac{2}{5}$)

While it cannot be denied that the expenses of introducing the system and the necessary experiments were greatly in excess of what was anticipated, that the amount received for the fecal material was less than was anticipated, and that the interest on the money and the instalment paid must be taken into account, yet a favorable judgment, as to the result, must remain. This trial of the Liernur system has proved at least this: That it is possible to remove all fecal material from tenements in an easy way, free from all annoyances, and that the collecting, loading and transportation thereof can be done wholly without odor, and before any results detrimental to health can arise from escaping gases. Therefore the great question concerning this matter is to be looked upon as entirely settled, and the system deserves recommendation to extension everywhere as well as in this city. Finally, there may be added to this that the expenses for experimenting, repairs, etc., for the current year 1873 are estimated at f2,000 00 (\$800 00)

While the produce of the fecal material,

at the rate of 1872, will amount to 1,407 60 (563 04)

Making a deficit of f592 40 (\$236 96)

It cannot be superfluous to mention, that although the nitrogenous elements upon which the value of the fecal material for the agriculture depends, and which Mr. Liernur estimated at 0.9 per hundred,

were found upon chemical examination to fall even below half this per cent.; and that Mr. J. C. Van de Blocquery, writing, as a farmer, to the Master of Public Works at Amsterdam (which letter appears in the public reports of that city for the year 1872, page 976), in the most positive terms expresses his special satisfaction with the results obtained by him with this fecal material at various trials on his land in the Haarlem lake polder. This letter closes with the following words: "I cannot comprehend what advantage there can be found in prejudicing the public against this manure, and calling it only sewer-water; and I regret this very much. By this opposition to the taking of the manure by means of a certain mixture (or composition), the town municipalities might easily be persuaded to give up a further extension or application of the Liernur system; and by this agriculture would suffer, beyond any doubt.

The Master of Public Works,

[Signed]

J. W. SCHAAAP.

It will be seen, from the letter of the mayor of Leiden, already given, that opinion has changed somewhat since the publication of this official communication, nearly three years ago.

EXPERIENCE IN OTHER COUNTRIES.

In Belgium and Flanders, human excrement has been used in agriculture from time immemorial, and the fertility of the soil is largely attributed to this fact. The nuisance, however, is great; and those substances which destroy the smell (the sulphates of iron, copper and zinc, chlorides of manganese and iron, etc.,) diminish the value of excrement as manure. In the more populous places, therefore, sanitary measures are beginning to be considered of more importance from year to year; and the idea has obtained that the first requisite is complete and inoffensive removal of filth. Very few of their cities, however, have yet undertaken any extensive works for this object. Brussels has a long intercepting sewer, discharging into, and seriously polluting the Senne, a small stream running through the valley and dividing the city into two parts. In 1861, and again in 1865, commissions were appointed to consider the subject of the disposal of the city's filth; the result of their investigation is embodied in the following extract from their report:

"The chemical (precipitating) processes employed up to the present day for separating the valuable parts of sewage have given unsatisfactory results. Irrigation only has proved sufficient for purifying sewage."*

The commission of 1865 visited the precipitating works at Leicester, England, and found that "the precipitates gave rise to an insupportably fetid odor, which extended a great distance."† An English (Belgian Public Works) Company has taken a contract to provide the city with a main-drainage system, of which irrigation with the sewage is to form a chief part. Imperfect irrigation is carried out at St. Étienne.

In Switzerland, subsoil-irrigation has been used to some extent without much success. A complete system of sewerage, with irrigation, is to be carried out for Zürich, as soon as satisfactory arrangements can be made.

Near Florence, an experimental sewage-farm was begun in 1874, and, thus far, has given satisfaction.

Two thousand acres near Milan have been successfully cultivated, under a system of irrigation, for many years. The sewage here is twenty times more dilute than that of Paris, or of most of the English cities.

In Spain, few rivers are polluted. The sewage of Valencia is used in irrigation; but, as is the case at Milan, it is the river that is used for this purpose, and it is simply an accident that its waters are polluted by the filth of a large city.

In the United States, a few insane-asylums are making attempts to utilize their sewage by irrigation. Mr. C. B. Lakin, at the State Asylum at Augusta, Me., has had excellent results from his experiments.

PROCESSES FOR PURIFYING SEWAGE.

Deodorization.

"Deodorizers" and disinfectants for sewage have been proposed,—in all more than sixty,—and used, in the laboratory at least, for the past century. Chloride of lime and perman-

* "Les procédés chimiques employés jusqu' à ce jour pour les extraire des eaux d'égouts ont donné des résultats peu satisfaisants; l'irrigation des prairies a seul promis d'utiliser et de purifier ces eaux d'une manière constante."

† "Les produits recueillis répandaient au loin une odeur fétide et insupportable."

ganate of potash are the only ones that have proved satisfactory, and their enormous cost makes it impossible to use them on a large scale.

The Metropolitan Drainage Commission of London made extensive experiments, in 1857, with all the prominent deodorizers that could be used without incurring inordinate expense. Their experience is summed up in the following words:—

“The most favorable result was obtained by the filtration of sewage through charcoal. The liquid which first passed off was quite clear and free from smell, but by analysis it was shown to contain a large amount of highly putrescible organic matter in solution. After a time it lost its color, and the smell returned. But, on continuing the process of filtration, the charcoal even loses its power; and consequently the expense of deodorization by this agent, even to the limited extent shown, becomes enormous.” Carbolic acid in large quantities, even when mixed with tar, only *arrested* decomposition; the effluent finally became turbid.

At Croydon, twenty years ago, there were tried, one after the other, lime, charcoal, carbolic acid, perchloride of iron, etc. Mr. Johnson, then chairman of the local board of that place, testified with regard to them as follows:—

“The failure was that they still left the sewage in so impure a state that the people on the river objected to the sewage being discharged into the river.”

He stated also that the reagents were all very expensive; so that irrigation was finally chosen as the cheapest and best method of disposing of the sewage.

Filtration.

Among the earliest experiments in England, filtration, both upward and downward, was attempted, the filters being made of sand, gravel, charcoal, sawdust, etc. This process has always failed to do more than intercept the solid portions of the sewage, and has now been abandoned, except in connection with irrigation.

The Sewage of Towns Commission of England, in their second report, speak of the experience of Birmingham, thus:

The downward system was soon given up as impracticable.

The upward filter was maintained in operation for some time longer, but was ultimately abandoned as practically useless."

. . . "The filters choke immediately, and become impervious to the passage of the liquid."*

The First Rivers Pollution Commission say: "As applied to sewage, disinfectants do not disinfect and filter-beds do not filter. Both attempts have been costly failures."

Intermittent Downward Filtration.

As the result of experiments in his laboratory, Prof. Frankland concluded † that land exposed alternately to the free action of the air and the sewage, would so oxidize and decompose and filter the latter, that it might be safely discharged into streams. In such case, it would be necessary to filter the sewage roughly before applying it to the land, in order to rid it of solid matter.

Mr. J. Bailey Denton has made the only practical trials of this method at Kendal, England, and at Merthyr Tydfil, Wales. One advantage is, that so small an area of land, one acre for each one thousand inhabitants, is sufficient for carrying out the system. Where only a few acres can be bought, especially if the soil is loose and open, it seems to be the most feasible plan for inland towns lying on small streams.

The Rivers Pollution Commission arrived at the following conclusions in regard to this process.

"Sewage traversing a porous and finely-divided soil undergoes a process to some extent analogous to that experienced by blood in passing through the lungs in the act of breathing. A field of porous soil, irrigated intermittently, virtually performs an act of respiration, copying on an enormous scale the

* In many cases, filters for ordinary drinking water have become so clogged in a short time as to render the water more impure after treatment than before.

† "The results of these experiments were to prove that intermittent downward filtration effects a very satisfactory purification of the water, when the amount of sewage does not exceed five and one-half gallons per cubic yard of filtering material in every twenty-four hours; and further show, by the presence of nitrogen in the form of nitrates and nitrites, that the process is essentially one of oxidation. The organic matter in the sewage stream is, to a large extent, converted into carbonic acid, water, and nitric acid; hence the necessity for the continual aeration of the filtering medium, which is secured by intermittent downward filtration."

lung-action of a breathing animal ; for it is alternately receiving and expiring air, and thus dealing, as an oxidizing agent, with the filthy fluid passing through it. The action of earth as a means of filtration must not be regarded as simply mechanical ; it is chemical, for the results of filtration, properly conducted, are the oxidation, and thereby the transformation, of the offensive organic substances, in solution in the sewage stream, into fertilizing matters which remain in the soil, and into certain harmless inorganic salts which pass off in the effluent water."

The requisites in practice are found by Dr. Dyke, from his experience at Merthyr Tydfil, to be as follows :—

"1. The soil of the land to be used must be porous.

"2. A main effluent drain, which must not be less than six feet from the surface, must be provided.

"3. The surface of the soil to be so inclined as to permit the sewage-stream to flow over the whole land.

"4. The filtering area should be divided into four equal parts, each part to be irrigated with the sewage for six hours, and then an interval of eighteen hours to elapse before a second irrigation takes place ; each of the four parts would thus be used for six hours out of the twenty-four. An acre of land, so prepared, would purify 100,000 gallons of sewage per day."

It was thought, at first, that when so great an amount of sewage was used it would be impossible to raise crops, but experience has proved the contrary to be the case. At Kendal, even a smaller amount of land has been used than at Merthyr Tydfil ; namely, five and one-half acres for 13,500 people ; and this disposes of an average of 975,000 gallons daily.

The cost of this system is somewhat greater than that of ordinary irrigation, inasmuch as the return from the crop raised is much smaller.

Precipitation.

The first experiments for accomplishing a solution of the sewage-question were made in Paris over a century ago,*

* The irrigation with sewage at Edinburgh was simply a financial project, and had no reference to sanitary requirements.

the object aimed at being the removal of the valuable parts of the sewage, so as to get them in a compact form.

To accomplish this result, over sixty different methods have been suggested at different times, most of them attempting some process of precipitation. Many of these methods are essentially repetitions of others which had been previously tried. All of them have proved failures.* No process at present known to the chemist, except the costly one of evaporation, can remove from sewage any large part of its valuable constituents in solid form. Hoffman and Witt show in the following table (the result of numerous analyses made for the Metropolitan Drainage Commission of London), that six-sevenths of the valuable matters of sewage are in solution :—

Value of One Hundred Tons of Sewage for Irrigation.

	Valuable insoluble matter.		Valuable soluble matter.		Total.
	s.	d.	s.	d.	s. d.
In its original state, ...	2	2½	15	4½	17 7
After treatment with lime, ...	—	—	11	11	11 11
After treatment with lime, sulphate of alumina and charcoal, ...	—	—	12	5	12 5
After filtration through charcoal, ...	—	—	11	1½	11 1½
After slaking with peat-charcoal, ...	—	—	10	11¼	10 11¼

In the first report of the Second Rivers Pollution Commission of England, are given the statistics from which the

* The testimony of Mr. Robert Rawlinson, C. E., C. B., now chief engineering inspector of the local government board, was given in the third report of the Sewage of Towns Commission, in 1865, as follows: "Experience, so far as carried, proves that fluid sewage cannot be manipulated into a solid manure so as to pay. There have been attempts at Leicester, at Tottenham, and, for a time, at Croydon. During the continuance and working of these sewage-works, there was the greatest possible nuisance, with no paying result. At Leicester, the solid which was expected to sell for four pounds per ton, could not be sold for four shillings a ton. At Birmingham, the sewage-sludge accumulated beyond the power to sell it for sixpence a ton. At Leamington, there is an annual cost, at the outlet works, of some £400 to precipitate and remove the sludge from about one million gallons of sewage per day. At Cheltenham, Coventry, Worksop, and at some other places, the separated sludge is sold at prices ranging from one shilling to two shillings per ton! In all these cases, the fluid—the true sewage—is wasted."

following table is condensed. The results are of experiments made July 30 and 31, and August 1, 1868, with the sewage of Leicester :—

Average Composition of Sewage.

[Results expressed in Parts per 100,000.]

COMPOSITION OF SEWAGE.	AVERAGE OF THREE DAYS.		
	Before any treatment.	After treatment by the lime-process.	After treatment by the A. B. C.-process.
<i>In Solution.</i>			
Total solid matters, ...	110.	91.66	120.33
Organic carbon, ...	3.344	2.570	2.374
Organic nitrogen, ...	.524	.248	.322
Ammonia, ...	1.550	1.975	2.333
Nitrogen, as nitrates and nitrites, ...	.007	.008	0.000
Total combined nitrogen, ...	2.096	1.903	2.244
<i>Suspended Matters.</i>			
Mineral, ...	23.15	3.19	1.59
Organic, ...	32.02	1.94	2.82
Total, ...	55.17	5.13	4.41

These tables furnish the key to the whole question, and show why the precipitating processes have all proved unsatisfactory. The effluent from them all is essentially *sewage*.

The more important of these processes are as follows :—

The Lime-Process.

Fresh milk of lime is added to sewage in varying quantities, generally about a ton of lime to 1,225,000 gallons of sewage.* They are thoroughly mixed, and after standing for some hours in settling-tanks, the mud settles to the bottom, and the liquid is drawn off. A slight flocculent coagulum is seen in the sewage during precipitation, and about one-fourth of the soluble organic matter is carried down, in part mechanically, in part as carbonate and phosphate of lime. A certain

* This quantity varies somewhat in different towns, according to the weather, the composition of the sewage, and its freshness or otherwise, etc., from three to sixteen grains of lime to a gallon of sewage. The precipitate weighs from four to five times as much as the amount of lime used.

portion of the ammonia is set free by the stronger alkali, and is one of the readiest vehicles of noxious vapors. The precipitate contains a large amount of sulphide of lime, a very unstable salt, which allows sulphuretted hydrogen to escape during the process of drying, giving rise to a very offensive smell. A small part of the sulphuretted hydrogen remains in the effluent. The fluid, therefore, is subject to ulterior change, and becomes itself a serious nuisance, unless mixed with a large quantity of flowing water, or purified by irrigation. Charcoal and other disinfectants have been used to remedy these evils, but they only increase the cost without materially changing the result. Experiments by Hoffman and Frankland show that, in the moderate climate of England, the effluent begins to putrefy after standing forty-eight hours; the addition of chloride of lime somewhat delays this process.

The famous Leicester bricks* were made, twenty years ago, of sewage treated by this process. Versmann gave them a value of seventeen shillings to the ton, while Voelcker estimated them to be worth fifteen shillings and fivepence. The processes of making these bricks cost three shillings a ton; their market price in 1866 was one shilling.† In some places in England they can hardly be sold at any price.‡

The lime-process was tried at Birmingham, where land for

* So called because the mud was dried in the shape of bricks.

† In 1870, four million gallons, the sewage of 95,000 people, were treated in this way, and the sludge was spread out on two acres and a half to dry. The yearly expense was £4,800; the "bricks" sold for £300, so that the loss was £4,500. As to the present condition, Dr. J. Wyatt Crane, health officer of Leicester, writes, under date of February 11, 1876: "Our sewers still discharge their contents into the river, but we are striving to diminish the amount of fecal matter as much as possible. We have adopted for this purpose, the system which originated in Rochdale, and which is called the pail system, and consists of a galvanized pail placed under the seat, which is removed once or twice a week, in a vehicle constructed for the purpose, and conveyed to a depot, where it finds customers among the neighboring farmers, and, I need not say, is an excellent manure. As a part of the system, the large ashpits, which were the receptacles for every kind of refuse, are done away with, and are constructed so small as to contain nothing but ashes. The better class of houses are supplied with water-closets, of which there were, three years ago, 8,400 in the whole town. The contents of these are carried into the sewers, and finally conveyed into the river. Parliament will be compelled to legislate ere-long upon this question."

‡ A large part of the phosphoric acid was found to be in an insoluble and comparatively valueless form.

irrigation could not be obtained ; but the trouble with it was so great, that the mayor and council sent a memorial to parliament, complaining "that the grosser and more solid matters contained in the sewage when so intercepted are in the condition of wet mud, the peculiar character of which prevents its drying so that it may be removed, and it is impossible to remove it until it has lain upon the surface of the earth for several months ; that the consequence of this state of things is, that since the first commencement of the system of interception, an area exceeding seven acres in extent is covered to a depth of four feet with such grosser or more solid parts of the sewage, and your memorialists are at present unable to remove it, for the reason already stated." The stench became so great, and the complaints so frequent, that an injunction was finally served against the city.

The effect upon the rivers of carrying out the lime-process is, that fishes return to them in some cases, and the streams become clear. Dr. Buchanan states that such was the case at Leicester, in 1866.* But the clarification of the sewage does not approach the standard of purity of the Rivers Pollution Commission.

The Alumina-Processes.

Alumina, especially when precipitated from its sulphate by lime, separates in a bulky form, and has the property of forming with organic matters somewhat stable compounds of gelatinous consistency, which carry down a considerable quantity of matter in suspension. The result is not very different from that of the lime-process. The whole of the phosphoric acid is saved, but not the ammonia. As so large an amount of foreign matter is added which has slight value as manure (720 pounds of clay and 120 pounds of sulphuric acid to each 150,000 gallons of sewage) the precipitate is of even less value than that obtained by the lime-process. An equally large amount of putrescible matter is allowed to escape by both methods, and the effluent becomes putrid in a short time.

These processes have been modified somewhat in different places in many non-essential details, and they have been

* Compare Dr. Crane's letter as to the present condition, page 329.

made the bases of extensive experiments in England, France, and Germany; but all agree in showing that the alumina-processes are more costly than the lime, the precipitate is of less value, and the effluent is equally putrescible.

The Superphosphate-Process.

This was supposed to fix the ammonia by forming a double phosphate of magnesia and ammonia; but this salt is soluble in water, especially in water containing common salt and other compounds found in sewage; so that the whole method is useless, beside being costly.

The Sulphite-of-Lime-and-Magnesia Process.

Sulphurous acid was expected to destroy the sulphuretted hydrogen, and it did so; but it is itself liable to change, and unless used in great excess is of little value. It was found in practice that decomposition took place in the effluent, causing offensive odors, while the precipitate was sold with difficulty at a shilling a ton.

The A. B. C.-Process.

The Messrs. Sillar patented this process, and so much was claimed for it, that the Rivers Pollution Commission of England made it the subject of one of their reports. The idea was got from the Mosaic law. The materials used, and their proportionate parts by weight, are as follows: Alum, 600 parts; blood, 1; clay, 1,900; magnesia, 5; permanganate of potash, 10; burned lime, 25; salt, 10; animal charcoal, 15; vegetable charcoal, 20; bi-carbonate of magnesia, 2.

From four to ten pounds of this mixture are stirred up with one thousand gallons of sewage until no further precipitate is produced. What effect eleven grains of blood are to have on a thousand gallons of sewage, it would be difficult to say.

The process now in use at Leeds is in accordance with the following modified formula: Alumina (impure sulphate), 400 parts (by weight); blood, 10; clay, 2,240; charcoal, 400. Total, 3,050.

Three times as much of this is used as of the original mixture.

The Rivers Pollution Commission give the following results of their examination of the Sillar process :—

"1. The process precipitates the greater part of the solid particles of the sewage, but in no case to such an extent as to allow the superincumbent waters to run into a river.

"2. The process produces no clearer water than what would have resulted if the sewage were allowed to settle by itself.

"3. The sewage is considerably reduced in value through it.

"4. Bad smells are always perceptible."

The precipitate was found to be of somewhat greater value than that obtained by the use of lime; but the proportional amount of cleansing of the sewage by the two processes was substantially the same.

Precipitation by Metallic Salts.

This has been found the most satisfactory of all the ways of removing the noxious ingredients of the sewage in solid form. The perchloride of iron has generally been used, as being the cheapest; though even that is too expensive for general use on a large scale. It settles readily in the form of a heavy precipitate of the peroxide, carrying down mechanically a very large part of the suspended matter. The sulphuretted hydrogen, too, is fixed in a stable form as a sesquisulphide. The ammonia, however, remains in solution, and the effluent putrefies to a certain degree, after a time.* The nitrogen and the phosphoric acid in the mud formed are in a condition to be used as manure, so that the precipitate has a greater theoretical value than some of the others. It sells for about the same price, however, as the difficulty of transportation is so great as to form the chief element in establishing its worth.

Suvern's System.

This process uses the following mixture: water, 240 parts; chalk, 100 parts; coal-tar, 18 parts; chloride of magnesium, 10 to 70 parts.

Experiments with this mixture have been made by a com-

* According to Hoffman and Frankland, in nine days during warm weather.

mission in Berlin, with the following results: The precipitate formed rapidly, leaving the fluid clear, but containing a large part of the ammonia. Few bacteria were found at once, but in a few days the effluent seemed swarming with living organisms. One thousand parts of the fluid contained 1.5 parts of solid matter and a large part of the urine in a decomposed condition. It was unfit to be run into the rivers. The precipitate contained 21.1 parts of organic matter in 100; and in this organic matter 0.7 per cent. was nitrogen and 1.5 per cent. phosphoric acid. It was found not to be worth enough to pay for cartage and labor, as the process costs sixty cents a year for each individual of the population.

Lenk's Process

Has been also tried by the same commission in Berlin. The mixture consists of alum, soda and chloride of iron or zinc. The precipitate formed slowly. The bacteria were not killed. The general results of these experiments were pretty nearly the same as by Suvern's process. Both methods were declared inferior to irrigation.

This list might be extended almost indefinitely, and seems to be limited only by the bounds of human credulity. In France and Germany the precipitating processes have been given up as inefficient. In England, a new "successful" patent process is hawked about every few months, to be soon found only an addition to the list of failures; and the public is perfectly bewildered by the maze of conflicting statements and propositions. In some cases, however, cities have been driven to the precipitating process because they could not get sufficient land to deal with their sewage in any other way. In such cases, the difficulty has been to get rid of the precipitate. An ingenious and satisfactory method of doing this has been recently patented by Major-General H. Y. D. Scott. It consists in burning the mud, and making cement of a very fair quality. It is not a remunerative procedure, but has been found quite satisfactory at Birmingham, where three tons are made each week.

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IRRIGATION.

The irrigation of land with sewage may be performed in one of three ways.

1. By the use of hose to sprinkle the land.
2. By the use of pipes under the surface.
3. By the use of open pipes or trenches on the surface.

The first is the simplest method, and one of the earliest suggested. It was soon abandoned, however, because experience has shown that it is best not to expose the leaves of growing plants to the direct action of any manure. It is of use on a small scale, with sufficient care in managing it.

Subsoil-Irrigation.

This method was practised in Switzerland at one time, but was soon found to be too costly for use on a large scale. For the disposal of the sewage of a small number of people, where there is an abundance of land, the system is an excellent one. It has been used by Mr. Rogers Field, C. E., of London, with admirable success. The sewage is carried to a safe distance from the houses in tight pipes, and is then distributed in open jointed pipes about one foot below the surface of the ground.* Subsoil-drains are placed at a depth of four feet to carry off the purified liquids. Col. G. E. Waring has used a similar method in Newport, which he describes as follows:—†

"The house drainage is discharged into a tightly-connected and thoroughly-ventilated tank. Its outlet-pipe, starting from a point one foot below the surface of the water, and about two feet below the cap-stone, passes out near the surface of the ground, and is continued by a cemented vitrified pipe to a point about twenty-five feet farther away. Here it connects with a system of open-jointed drain-tiles, consisting of one main fifty feet long, and eight lateral drains six feet

* Mr. Field is of the opinion, from his experience, "that four perches would be sufficient ground for the effective disposal and utilization by sub-irrigation of the slops from an ordinary cottage." [*On Excrement Nuisances*, by Mr. J. Netten Radcliffe; Second Report of the Medical Officer of the Privy Council and Local Government Board of England, p. 233.]

† "The Sanitary Drainage of Houses and Towns," *Atlantic Monthly Magazine*, No. 216, 1875, p. 428. It should be said that earth-closets were used by Col. Waring, as an adjunct to this system.

apart, and each about twenty feet long. These drains underlie a part of the lawn, and are only about ten inches below the surface." If made again, he would have the pipes three feet apart. The slope from one extreme of the system to the other is only fifteen inches. The pipes require cleaning about once a year.

Surface-Irrigation.

In Egypt and in India surface-irrigation has been used on an enormous scale. In Lombardy and Piedmont many million acres of land are so irrigated at the present day.* In all these places, the process has been carried out simply with reference to the large profits which result from it. No sanitary laws are considered. In fact, the irrigated fields are at some seasons of the year covered with a stagnant fluid, and diseases of the intermittent type are prevalent.

The experience of these countries led some private individuals in Edinburgh to make a similar attempt there about two centuries ago. The result could not then have been satisfactory, as the scheme was not extended until about a century and a half later.

Thirty years ago, an experiment was made in England in utilizing the sewage of one of the insane-asylums of the kingdom,† and ten years later Rugby, Croydon, and a few other towns took the lead in attempts to *purify* sewage by irrigation, without any view to large profits.‡ Their experi-

* In the valley of the Connecticut River a large area is so fertilized from being overflowed by the yearly rise of the water, that it requires no other manure. This natural irrigation has brought the land to a high state of fertility; so also in the Mohawk Valley, and probably in others throughout the country.

† In 1848, the Metropolitan Sewage Manure Company used the sewage of a part of London to irrigate their garden near Fulham. Strawberries and other fruits were raised, as well as vegetables. The experiment proved satisfactory in every way, except that it was not successful financially. The company could not compete with other farmers who brought back from the city in their market-wagons (otherwise empty) stable-manure which they bought there at low rates.

‡ This was recommended as a sanitary measure by Mr. Edwin Chadwick, in 1842. In the first report of the Health of Towns Commission, Mr. P. H. Holland states that such operations must prove remunerative when properly conducted; an opinion which is now gaining ground, in spite of numerous failures.

The First River Pollution Commission quote and indorse the following

ence was such as to give the impression that large profits were to be made in the work ; and the high theoretical value given to sewage by Baron Liebig, in his letters, only encouraged this idea. In individual cases, it was found that by soaking the ground with sewage, without special attention to sanitary laws, enormous crops of grass could be raised at slight cost. The products of a single acre at Edinburgh sometimes sold for over two hundred dollars ; but it was soon found that there is only a limited demand for fresh grass in any town, and that irrigation, to be carried on so as to avoid offence, is not a cheap process.

The Sewage of Towns Commission of England tried some very interesting experiments at Rugby in 1861, 1862, and 1863, and their results, the most complete ever obtained, are given on the following page.* The land was divided into four parts, and treated,—

Lot 1. Without sewage.

2. With 3,000 tons of sewage per acre per annum.
3. With 6,000 tons of sewage per acre per annum.
4. With 9,000 tons of sewage per acre per annum.

The different plots were of the same size, and as nearly alike in other respects as possible.

Another table is given (see p. 338), showing the per cent. of dry substance found in the various crops. The plots and the quantities of sewage used on each are as in the table on page 337. The crop raised each year was meadow-grass.

statement of the Sewage of Towns Commission: "When local circumstances are favorable, and undue expenditure is avoided, towns may derive profit more or less considerable by applying their sewage in agriculture. Under opposite circumstances, there may not be a balance of profit; but even in such cases, a rate in aid, required to cover any loss, need not be of large amount."

* Third Report, Sewage of Towns Commission, 1865, p. 6.

Results of Three Years' Experiments at the Sewage-Farm in Rugby. Grass raised in 1861, 1862, 1863, measured in tons, cwt.s., qrs., and lbs.

Y E A R.	FIVE-ACRE FIELD.				TEN-ACRE FIELD.			
	Without Sewage.		With Sewage.		Without Sewage.		With Sewage.	
	Lot 1	Lot 2	Lot 3	Lot 4	Lot 1	Lot 2	Lot 3	Lot 4
1861, . . .	tons. 9 5 3 5 cwt.s. 5 3 1 0 qrs. 5 3 1 0 lbs. 5 3 1 0	tons. 14 16 3 8 cwt.s. 27 18 0 18 qrs. 27 18 0 18 lbs. 27 18 0 18	tons. 27 1 0 10 cwt.s. 34 10 0 19 qrs. 34 10 0 19 lbs. 34 10 0 19	tons. 32 16 3 8 cwt.s. 32 9 2 22 qrs. 32 9 2 22 lbs. 32 9 2 22	tons. 8 18 0 15 cwt.s. 16 10 0 25 qrs. 16 10 0 25 lbs. 16 10 0 25	tons. 15 16 3 2 cwt.s. 27 11 0 20 qrs. 27 11 0 20 lbs. 27 11 0 20	tons. 22 15 2 12 cwt.s. 32 2 1 14 qrs. 32 2 1 14 lbs. 32 2 1 14	tons. 26 13 3 12 cwt.s. 31 12 1 20 qrs. 31 12 1 20 lbs. 31 12 1 20
1862, . . .	tons. 8 3 1 10 cwt.s. 4 18 3 13 qrs. 4 18 3 13 lbs. 4 18 3 13	tons. 27 18 0 18 cwt.s. 22 5 0 11 qrs. 22 5 0 11 lbs. 22 5 0 11	tons. 34 10 0 19 cwt.s. 34 18 1 27 qrs. 34 18 1 27 lbs. 34 18 1 27	tons. 32 9 2 22 cwt.s. 37 0 2 5 qrs. 37 0 2 5 lbs. 37 0 2 5	tons. 8 0 3 19 cwt.s. 16 10 0 25 qrs. 16 10 0 25 lbs. 16 10 0 25	tons. 25 5 1 8 cwt.s. 27 11 0 20 qrs. 27 11 0 20 lbs. 27 11 0 20	tons. 30 11 2 12 cwt.s. 32 2 1 14 qrs. 32 2 1 14 lbs. 32 2 1 14	tons. 34 19 1 21 cwt.s. 31 12 1 20 qrs. 31 12 1 20 lbs. 31 12 1 20
1863, . . .	tons. 7 9 1 9 cwt.s. 7 9 1 9 qrs. 7 9 1 9 lbs. 7 9 1 9	tons. 21 13 1 12 cwt.s. 21 13 1 12 qrs. 21 13 1 12 lbs. 21 13 1 12	tons. 32 3 1 0 cwt.s. 32 3 1 0 qrs. 32 3 1 0 lbs. 32 3 1 0	tons. 34 2 1 12 cwt.s. 34 2 1 12 qrs. 34 2 1 12 lbs. 34 2 1 12	tons. 11 3 0 10 cwt.s. 11 3 0 10 qrs. 11 3 0 10 lbs. 11 3 0 10	tons. 22 17 3 1 cwt.s. 22 17 3 1 qrs. 22 17 3 1 lbs. 22 17 3 1	tons. 29 9 3 13 cwt.s. 29 9 3 13 qrs. 29 9 3 13 lbs. 29 9 3 13	tons. 31 1 3 18 cwt.s. 31 1 3 18 qrs. 31 1 3 18 lbs. 31 1 3 18
Average, . . .								

Per cent. of dry substance in Crops.

NUMBER OF CROP.	FIVE-ACRE FIELD.				TEN-ACRE FIELD.			
	Without Sewage.	With Sewage.			Without Sewage.	With Sewage.		
		1	2	3		4	1	2
1861.								
1, . . .	27.9	30.5	26.9	27.7	22.	23.3	21.4	18.4
2, . . .	24.4	19.8	14.2	13.3	26.9	17.1	15.1	16.1
3, . . .	—	13.4	13.7	12.9	—	12.6	7.3	14.4
4, . . .	—	—	15.4	9.6	—	16.9	15.1	17.8
Mean, . .	26.2	21.2	17.6	15.9	24.5	17.5	14.7	16.7
1862.								
1, . . .	26.7	22.8	14.4	15.3	26.9	19.5	13.5	13.1
2, . . .	22.8	14.3	16.4	19.4	17.9	16.2	19.	16.7
3, . . .	—	18.2	12.9	14.2	—	14.5	14.4	15.8
4, . . .	—	—	—	—	—	—	33.8	33.8
Mean, . .	24.8	18.4	14.6	16.3	22.4	16.4	15.6	15.2
1863.								
1, . . .	36.1	21.5	17.6	16.3	39.8	18.6	20.	14.6
2, . . .	34.4	18.5	14.9	17.8	18.2	17.7	16.3	18.8
3, . . .	—	17.7	10.9	17.6	—	12.4	14.6	15.2
4, . . .	—	15.8	13.	12.3	—	—	13.9	13.6
5, . . .	—	—	—	15.3	—	—	—	—
Mean, . .	35.3	18.4	14.1	15.9	29.	16.2	16.2	15.6

The results of analyses by J. B. Lawes are given in the following table, and show the effect of sewaged grass on the milk of cows :—

	COWS FED ON GRASS ALONE.		COWS FED ON GRASS AND OIL-CAKE.	
	Unsewaged, mean of nine samples.	Sewaged, mean of ten samples.	Unsewaged, mean of four samples.	Sewaged, mean of four samples.
Caseine, . . .	3.246	3.241	3.352	3.423
Butter, . . .	3.604	3.430	3.657	3.707
Sugar of milk, etc., . .	4.405	4.218	4.561	4.689
Mineral matters, . .	.753	.776	.740	.771
Total solids, . . .	12.008	11.665	12.310	12.050
Water, . . .	87.992	88.335	87.690	87.950
Total, . . .	100.	100.	100.	100.

The commissioners state, as the result of their experiments, that "analysis shows very little difference in the quality of the milk yielded respectively from sewaged and unsewaged grass. The difference in composition, such as it is, is slightly in favor of the milk from the unsewaged grass, when grass was given alone, and slightly in favor of the sewaged grass when oil-cake was given in addition."

The First Rivers Pollution Commission say: "The grass is not only wholesome, but cows fed upon it give richer milk, from which first-class butter is made."

Lawes and Way give the following summary of the whole series of investigations, extending over three years:—

"Taking the average over three years, and in the two fields, the amount of produce obtained without sewage was about $9\frac{1}{4}$ tons of green grass per acre per annum, equal to about three tons of hay; and with 3,000, 6,000 and 9,000 tons of sewage per acre per annum, the amounts were, respectively, about $22\frac{1}{4}$, $30\frac{1}{4}$ and $32\frac{1}{2}$ tons of green grass, equal, respectively, to about 5, $5\frac{3}{4}$ and $6\frac{1}{2}$ tons of hay.

"When cut and given to fattening oxen tied up under cover, more sewaged than unsewaged grass, reckoned in the fresh or green state, was both consumed by a given weight of animal within a given time and required to produce a given rate of increase; but of real dry or solid substance less of that of the sewaged than of the unsewaged grass was required to produce a given effect.

"When cut grass was given alone, the result was very unsatisfactory; but when oil-cake was given in addition, the amount of increase upon a given weight of animal within a given time, and for a given amount of dry substance of food consumed, was not far short of the average result obtained when oxen are fed under cover on a good mixed diet.

"When cows were fed on unsewaged or sewaged grass, as much as they chose to eat, a given weight of the animal was more productive, both of milk and increase, but especially of milk, on the unsewaged than on the sewaged grass.

"From a given weight of unsewaged grass, reckoned in the fresh or green state, more milk was produced than from an equal amount of fresh sewaged grass; but a given weight of the dry or solid substance supplied in sewaged grass was,

on the average, more productive than an equal weight supplied in unsewaged grass.

"By the aid of sewage, the time that an acre would keep a cow, and the amount yielded from the produce of an acre, were increased between three and four fold.

"The sewaged meadow grass, as cut and given to the animals, contained a less proportion of dry or solid substance than the unsewaged.

"The proportion of nitrogenous, and also of impure waxy or fatty matter, was much greater in the solid matter of the sewaged than in that of the unsewaged grass."

The Mode of Distributing Sewage.

This will be best understood from a description of individual farms. A few of the principles only will be given here.

In the first place, the land must be prepared so that the beds shall have a slope varying from 1 in 50 to 1 in 150. If not loose and porous, the land must be underdrained.* The sewage must be delivered (by pumping if necessary) at the highest point on the farm, whence it is distributed by gravitation.

The main carriers may be open, and of cement, or, preferably, of Scotch clay pipe. The laterals are generally simple trenches dug in the earth, a few inches deep. On some farms the main conduits are simply trenches dug in the ground. Of course they require frequent cleansing to prevent deposits on their sides and bottoms.

The sewage flows uniformly over the surface of the land, each plot being irrigated for a few hours at a time, and once in every three to twelve days, as is necessary; grass, for instance, may be treated much oftener than vegetables.

The accompanying plates illustrate the process as generally used.

Fig. I represents the process as generally used. A F is the main sewage-delivering conduit, which is dammed at various points, as required, by the gate F. By opening the gates G, any trench, B D, C, etc., may be made to distribute

* The amount of underdraining generally found necessary in ordinary farming is sufficient, and the same rules apply to both cases.

Fig. 1.

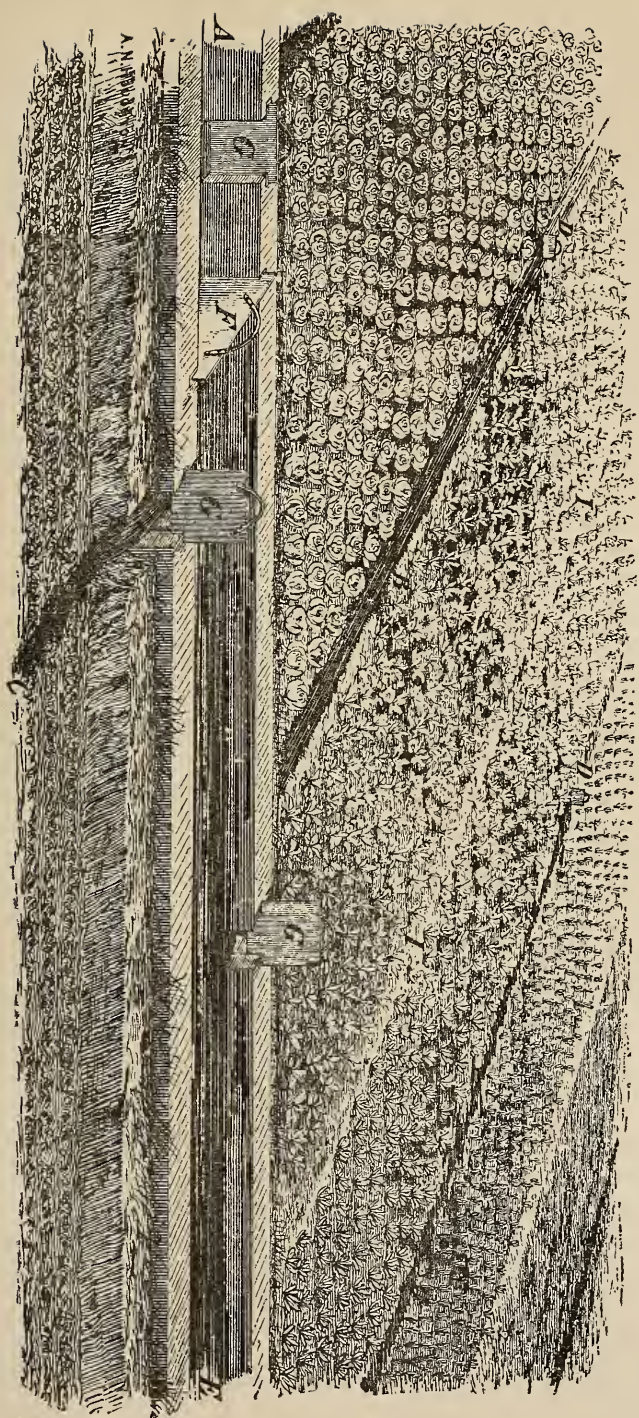


Fig. II.



the sewage over any part of the field, and the flow is limited by placing the dam D at any point desired. The fluid flows from the two trenches, B D, for instance, toward the lower point, I I; that part of it which is not absorbed and assimilated by the roots of the growing plant, gradually sinks into the ground and mingles with the ground-water, and finds its way into the neighboring streams, either by gravity directly through the soil, or by the deep pipe-drains.

Fig. II represents a modification of the process, which is admirably adapted to mild climates, as in England. The flow of the sewage can be readily limited to any particular area by means of the jointed half-pipes B, which can readily be turned in their places with the foot.

Location of Sewage-Farms.

The testimony of two distinguished English authorities before a parliamentary committee, that sewage-farms are "pestiferous swamps," added to the experience of bad smells from the flooded and ill-managed meadows near Edinburgh, led people, naturally enough, to think that irrigation with sewage should be carried on only at points remote from human dwellings. But it was soon found that all sewage-farms were not nuisances; and careful investigations in France, Germany and England have failed to bring to light a single case of injury to health, or of offence arising from sewage-irrigation properly conducted. The First Rivers Pollution Commission say in their final report: "When foul smells are complained of as coming from sewage-irrigated lands, the causes are in the state of the sewage, or in the rude way of using it."

At this time, objection is seldom made to having sewage-farms one mile from towns. At Croydon, six years after irrigation began, land in the immediate vicinity of the farm had increased in value from £250 to £1,000 per acre. This could not have been the case if the farm had been a serious drawback to living in that neighborhood.

Public institutions in England often irrigate with sewage land a few rods from their walls. The high price of land in the immediate vicinity of cities makes it necessary to go four

or five miles ; and that is the distance at which sewage-farms are usually found.

Amount of Land Necessary.

Mr. W. Hope, of Breton's Farm, Romford, states that an annual application of five thousand tons to the acre gives the best practical results from sewage-farming. This would be about one acre of land to each one hundred individuals ; an estimate concurred in by the Sewage of Towns Commission. The Rivers Pollution Commission prefer one acre for every one hundred and fifty people. The Earl of Warwick, however, who has one of the most successful farms in England, has one acre of land for every sixty people.

Of course the amount will depend somewhat upon the character of the soil and the climate. In Dantzic, one acre of their sand is deemed sufficient to purify the sewage of six hundred people. In Berlin, the result of ten years' investigation is that seven hundred and fifty acres will be sufficient for their whole population of 750,000. On the Craigentenny meadows near Edinburgh, from 20,000 to 100,000 tons of sewage are flooded on an acre of land each year, making virtually in some places a swamp over which cattle cannot walk without sinking.

The Effect of Climate.

In England, Scotland and France, no difficulty is found in irrigating throughout the winter. The sewage soaks into the soil, and the effluent is nearly as pure as in summer. The land, however, is ploughed in the spring, sown with some cereal, and not irrigated during the following summer. In the colder climate of Berlin, where the ground sometimes freezes to a depth of three feet, some difficulty was expected ; but experiments have shown that irrigation will be successful the year through. In winter the sewage keeps warm enough under ice and snow to soak into the ground and become purified. Its purification is not as complete as in summer, but sufficient to allow it to be discharged into the rivers. At Dantzic, where the climate is quite similar to that of Massachusetts, sewage-irrigation has been interrupted only one winter by the cold, and then for only a few days at a time.

In dry climates, of course, sewage-irrigation is more successful than in moist.

Theory of the Purification of Sewage.

The action of vegetation is the chief element in purifying sewage by irrigation, although this is supplemented by a certain amount of filtration and oxidation by the soil.

Liebig thought that all matter must be in a soluble form to be assimilated by the roots of plants; but later investigators have come to different conclusions.

Mayer, in his "*Lehrbuch der Agriculturchemie*," published in 1871, states that rootlets themselves have the power * of assimilating substances which are insoluble. He also quotes Gazzeri, Taddei and Mulder, in support of his theory.

Gazzeri and Taddei found that coagulated albumen in suspension in water rapidly disappeared when the roots of a growing plant were placed in it, leaving a clear fluid; without the presence of the plant it remained turbid.

M. Jeannel reported to the *Académie des Sciences*, in 1872, similar results from exhaustive experiments with water containing vegetable and animal matter in suspension. He placed macerated fruit in water; and when the mixture had become thoroughly turbid and putrid, he divided it into two parts; that in which the roots of growing plants were placed soon became clear, while the others did not. The same evidence was obtained by using putrid meat.

Dr. Alfred Carpenter has verified these experiments by a careful and thorough series of investigations.†

The theory seems well grounded, and, if proved true, is an additional argument in favor of sewage-irrigation.

The Effluent from Sewage-Farms.

The water, as it passes off from sewage-farms, is often so pure as not to reveal any evidence of contamination to the chemist. On some farms it runs into brooks from which the

* " . . . aktive Fähigkeit ungelöste Substanzen, die mit den feinsten Wurzelverzweigungen in unmittelbare Berührung kommen, in Lösung überzuführen und in sich aufzunehmen."

† "The Power of the Soil, Air and Vegetation to Purify Sewage. [Sanitary Record, May 1 and 8, 1875.]

cattle and horses drink, and in many cases it has been used freely by workmen and others for years without any bad effect. It is the only effluent which comes up to the standard required by the Rivers Pollution Commission of England. By this rule, no water is allowed to run into streams if it contains, for every 100,000 parts, more than two parts of organic carbon and three-tenths of one part of organic nitrogen in solution, and in suspension three parts of inorganic matter, and one part of organic matter.

Of course, sewage-farms may be, and undoubtedly sometimes are, so badly managed that this degree of purification is not attained. In no case is it entirely safe to drink water which has once been contaminated with human excreta containing the "germs" of disease, unless it has been exposed to a sufficiently high temperature, or has stood long enough for these "germs" to become inert. How long this time must be, we do not yet know.

Alleged Ill-Effects.

It is worth while to consider this subject somewhat briefly. Drs. Cobbold and Letheby at one time thought that the risk of parasitic disease in cattle was great, if they were fed on sewage grass. That fear has proved groundless. The meat has been examined, microscopically and otherwise, on Mr. Hope's farm, and found to be uninjured. The milk and butter from cows fed on sewage grass have been used freely by old and young for many years without a single case of injury from it.

In 1873, Mr. Smee wrote to the "London Times" that on his farm cows fed on sewage grass gave bad-tasting milk, and that butter made from it soon became rancid. Mr. W. Hope, than whom no one is more qualified to give an opinion, said that these ill-effects probably came from the fact that sewage was allowed to lie several days to a considerable depth over the grass. He also said that, in all his experience, he had never known a single such case on a well-conducted farm.*

* It is a well-known fact that soil sodden with simple water produces root-crops which are far from palatable. In one case, near Boston, such a field received the sewage from two cesspools, and the potatoes raised there were even offensive to smell and taste when prepared for the table.

Dr. Phillips, superintendent of the Devon County Insane Asylum, said that his cows were fed almost wholly on grass irrigated by the sewage of the eight hundred inmates of his institution; that they gave excellent milk, from which the best of butter was made.

Mr. Hale, director of one of the industrial schools, added his testimony as follows: The sixteen hundred residents in the school had for four years used milk and butter freely, with the best results; the cows from which they got their supplies were fed chiefly on sewage-grown grass. Formerly, when the sewage was allowed to collect in the fields, and so became stagnant and putrid, his experience had been different.

Dr. Alfred Carpenter states that he has used such milk freely in his own house, and has watched its effect carefully in Croydon, where the processes are conducted with care. He has never seen any bad results.

The testimony is overwhelming on this point.

No cases of illness have been traced to emanations from well-ordered sewage-farms. Even in Edinburgh, where they are carelessly managed and foul-smelling, this has been the case. In fact, during the cholera-epidemics of 1859 and 1866, this region enjoyed complete immunity from the disease.

The only authentic case of illness, probably caused by sewage-irrigation, was reported by Dr. T. S. Clouston, in the "Medical Times and Gazette," June, 1865. He shows that several severe, and some fatal, cases of dysentery had, probably, been caused in the Cumberland and Westmoreland Asylum, by emanations from a sewage-irrigated plot of land, three hundred and fifty yards from the wards, with a stiff clay subsoil, not underdrained. The method of irrigation, however, was not, in all respects, satisfactory.

The Cost of Irrigation.

Sewage-farms have thus far seldom proved remunerative, and for many reasons.

1. Excessive and fallacious estimates of the value of sewage led to the construction of costly works, so that the interest on the money invested was very great.

2. Enormous rents have often been required by landowners,—often sixty or seventy dollars a year for a single acre

of land. Land has often been bought, too, at such high prices (\$2,500 to \$5,000 an acre), that no farming could be carried on with profit upon it.

3. The high position of many sewage-farms, and the character of the soil, have often required great outlays for pumping-apparatus, grading, etc.

4. The necessity of *purifying* the sewage, at all events, creates the necessity of using it at times when it cannot benefit, and must even harm, the crops.

5. The uncertainty due to the amount of rainfall is often sufficient to turn a profitable use of sewage on land to actual loss.

6. Sewage-farms have been usually managed by local boards. If an ordinary farm were to be managed by them, the result would, undoubtedly, be the same.

The Earl of Warwick has, at Leamington, an admirably-conducted sewage-farm, one of the few in England which are carried on by private enterprise. He pays £450 a year for the sewage from a population of 20,000; and it is generally agreed that his investment has proved a good one.

Except under favorable natural conditions, sewage, on account of its extreme dilution, is expensive to handle, and is of little value as compared with other fertilizers. The sewage of most English cities is so diluted, that one ton of Peruvian guano has the same value as 1,250 tons of sewage. In American cities, where twice as much water is used, its value would be only one-half as great. Water, however, is one of the best of disinfectants, and a copious dilution of sewage is necessary to the health of the inhabitants of populous districts. The pecuniary sacrifice, if any, entailed by such dilution, must of necessity be endured.

At Dantzic, where all of the sewage of the city is used in irrigation, the amount of water used in flushing the sewers makes the total amount carried off about as great as that used in American cities. At Munich, where irrigation will, in all probability, finally be used, the amount of water used for flushing the sewers alone, amounts to 100 gallons to each individual of the population, at each flushing.

In England, however, a few towns have introduced the separate system of sewers, so as to have their sewage as con-

centrated as possible, before using it in irrigation ; but it is doubtful whether the advantage gained may not be more than counterbalanced by the evils arising from imperfectly-flushed sewers.

German investigators, and especially Varrentrapp, have insisted that the mercantile aspect of the question must be ignored, and that purification of sewage must be rendered complete, on sanitary grounds alone, whatever the cost.

METHODS OF DISPOSING OF SEWAGE.

Manchester, England.

With a population of 356,600, living on 4,516 acres, a very large proportion of them being of the improvident class, this city adhered until quite lately to the cesspool-system, discharging its surface-drainage and kitchen-waste into the rivers Irwell, Irk and Medlock, which became filthy to the last degree. About 50,000 of the inhabitants, including those at hotels, are now supplied with water-closets, and from these also the discharge is into the rivers. The better classes live for the most part outside of the city limits ; but, whether within or without, they insist upon having water-closets in their houses.

In the vain hope of keeping the sewage pure enough to discharge into the rivers, the Health Committee have been abolishing cesspools,* and substituting the pail and cinder-sifter privies already described.† These ash-pits are very satisfactory where the water-carriage system is not practicable, but the method of emptying them is costly, and not entirely without offence. One hundred carts are constantly employed in Manchester, removing a mass of ashes and excrement, which has some high theoretical value. It is piled up just at the edge of the city, and in winter sells rapidly for a shilling and a half a ton. In summer the farmers give only a penny

* In 1872 and 1873, 4,000 cesspools were emptied, the black and saturated soil underneath was removed, and the cavities filled with clean earth. This method should always be followed in getting rid of these nuisances. In many public and private buildings, buried and concealed filth finds one outlet after another for its poisonous gases, whenever the attempt has been made to shut the smell out by closing one escape-hole after another. It is the old experiment of nailing down the safety-valve of a boiler.

† See page 182. Fifteen thousand have already been introduced.

and a half, and, during the busy season, will not always give that.

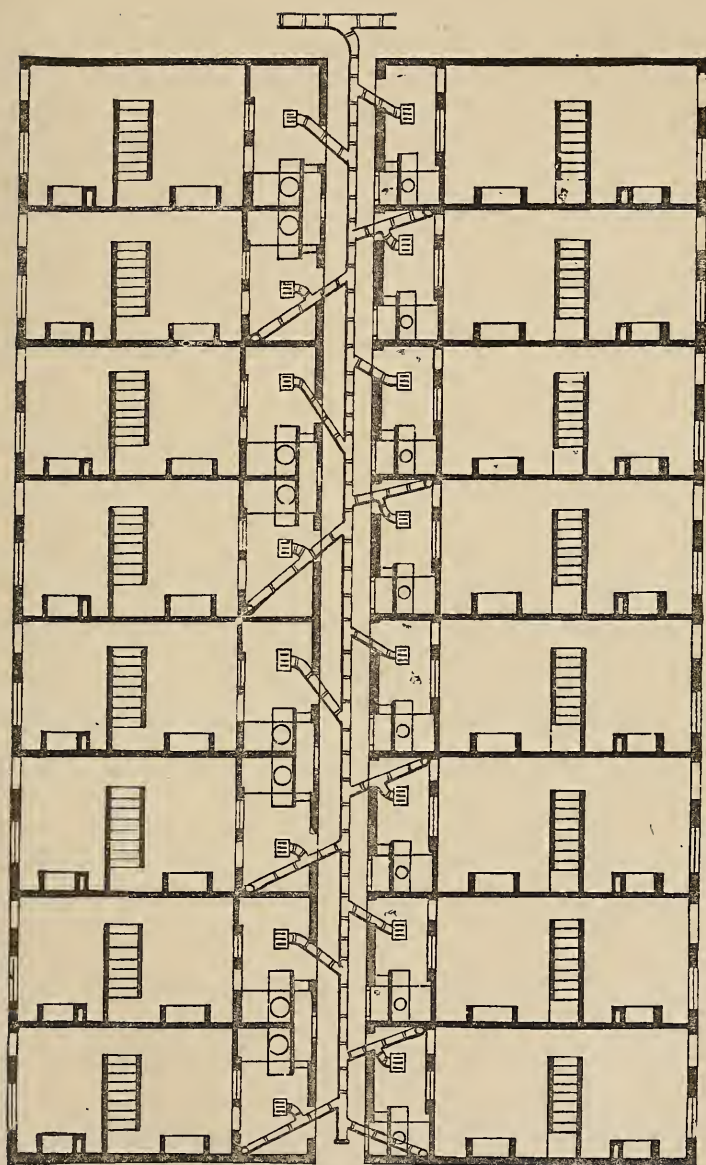
As will be seen by the annexed plan, taken from the report for 1874 of Dr. Leigh, Medical Officer of Health for Manchester, the ashpit system requires the construction of sewers, in order to carry off the fluid refuse, sink-slops, etc. To connect these sewers with the 60,000 houses of Manchester, would require an outlay of £60,000, of which the annual interest would be £2,400. The present annual cost of removing excrement by carts is about four times this sum, or £10,000; while Dr. Leigh, the medical officer of health, in his last report, shows the necessity of purifying the sewage before letting it run into the rivers.

The rate of mortality in Manchester is still very high, although it has fallen about five per cent. in the last seven years. The city has an insufficient water-supply, and is densely populated. These causes undoubtedly contribute largely to the high death-rate, although the latter has been attributed by some solely to the want of speedy removal of the filth by water-carriage. The ashpits are emptied only once a week.

Leeds.

This city has sewers for about two-thirds of its population, and water-closets are largely used. In 1871, an injunction was served upon the authorities, forbidding them any longer to pollute the river Aire, and they were not allowed to carry their sewerage-system any farther until they purified their sewage. Finding some difficulty in obtaining land, they tried several of the precipitating processes, one after the other, finding them all failures.

During the past summer they began to use again the A. B. C.-process. They have 12,000,000 gallons of sewage to treat daily, making about 200 tons of precipitate. This they were not able to sell at any price during the past summer. In the process of drying it was quite offensive, but when dry it was free from smell. As a manure, it is thought by the Sewage Utilization Committee of Leeds to have considerable value, as is shown in the following list (the result of two years' experiments by the committee), in which different fertilizers are arranged in the order of their value as manure:—



Plan showing Privies (Ash-Closets) and Sewers, Manchester, England.

1. Stable-manure.
2. Native guano (from A. B. C.-process).
3. Peruvian guano.
4. Native manure (mixture of No. 2 and night-soil).
5. Sewage-mud.
6. Street-sweepings.

These results do not correspond with those obtained in Paris, Brussels, Berlin, and by the various royal commissions in England; but cartage, in this case, amounted to nothing, as the land was close to the works. If the precipitate is so valuable, it is difficult to see why the farmers do not buy it.

The process of precipitation is as follows: The sewage passes slowly through six iron tanks in succession, each fifty feet square and ten feet deep. A deposit takes place in all of them, and is removed when it become a foot deep. The effluent, as it passes from the tanks, is somewhat turbid, and without disagreeable odor; but it soon putrefies. Preparations are making for using it in irrigating large beds of osiers so as to purify it before final discharge into the river, which is now so polluted that it is difficult to distinguish the water, by its appearance, from fresh sewage. There is no offensive smell* about the works, near the pumps or elsewhere, except from the moist precipitate.

The original cost of the works, exclusive of sewers, was £80,000, of which the annual interest would be £3,200. The annual outlay is £15,000. The annual income, supposing that the manure found a sale at two shillings a ton (which it does not) would be only £7,300, showing an annual deficit of £10,900.

Birmingham.

Following the provisions of the Public Health Act of 1848, this city expended £200,000 in constructing sewers with their outlets into the rivers Rae and Tame, one of which is six feet and the other twelve feet wide. In 1858 the pollution had become so great that a chancery injunction was served upon the city to prevent the continuance of the evil.

The council then proceeded to build two sets of tanks, each

* The sewage is delivered fresh. The sewers, 120 miles in length, have 13,000 free openings into the streets for ventilation.

one being 360 feet long, 90 feet broad and 6 feet deep, in which the bulk of the matters in suspension in the sewage was deposited, and there were thus arrested about 120 cubic yards of slush a day. The effect on the river is described by Alderman Osborne as follows :—

“The sewage of the borough is discharged into the River Tame, but subject to some slight purification; . . . a portion of the solid matter is removed, but scarcely any of that which is held in solution, so that a very large proportion of the latter passes off into the river, and in a short time, varying with the temperature, undergoes decomposition, thus polluting the stream.”

In 1866 and 1867, complaints were again made of the state of the river, and it was decided to try the effect of purifying a portion of the sewage on about 130 acres of land, by means of irrigation. This was so far successful that it was determined to recommend the council to take the sewage about eight miles from its present outlet, and to purify the whole in the same way on 2,500 acres of land. This was objected to on account of the high price demanded by the owners of the land, and another committee decided upon taking 800 acres for intermittent downward filtration, combined with irrigation. This was approved by the council, and a bill was introduced into the House of Commons, which was defeated by three votes on the third reading.

In the meantime the sewage-precipitate was amassed, to dry, in such vast quantities that it became itself a nuisance, and another injunction was obtained.

That is to say; the city, in accordance with an Act of parliament, built sewers, was compelled to introduce water-closets, and was advised to discharge its filth into the most convenient stream. It was then compelled by chancery injunction, under a later Act of parliament, to keep its filth out of the stream. While using the best practicable method for doing this, it was served with another injunction to prevent a nuisance created in the very process of removing the former one. Defeated in parliament in its attempt to obtain land for a sewage farm, which was the method recommended, as the only satisfactory one for purifying sewage, by all the royal

commissions appointed to investigate the subject, it was difficult to know what to do.

It was then decided to clarify the sewage by the lime-process, using twelve tons of lime a day. Accordingly, four additional sets of tanks were built, of four compartments each, at a cost, including engine, etc., of £70,000. These sixteen tanks are each 150 feet long, 50 feet wide and 6 deep. The annual outlay, exclusive of interest on the capital invested, was, in 1874, £13,000; this year it has probably been more. The precipitate to be disposed of daily is 350 cubic yards, and it sells for a trifle over a shilling a ton (thirty shillings for a boat-load of twenty-five tons). Only a small quantity, however, can be disposed of at that price.

The whole sewage of the city is now treated at the works by five different methods.

1. Simple irrigation with the raw sewage. One hundred and thirty acres, all that can be got, are irrigated with a small portion of the sewage. The land is underdrained at a depth of four feet, and the effluent is so pure as to be freely used by the workmen for drinking. The main and lateral sewage-conduits are shallow trenches dug in the earth. The vegetables raised are sold freely in the market, and there is said to be no prejudice against them, many persons even preferring them. Farmers in the vicinity of the works ask for, and receive, free of charge, sewage for irrigating their lands.

2. Irrigation with the effluent, after it has passed through seventeen tanks for precipitating the suspended matters. It is somewhat turbid in appearance, and is used in precisely the same manner and quantity as the unclarified sewage. The manager and the farm-hands consider it fully as valuable as manure; the crops in the two cases look equally well.

3. There was so great complaint from the offensive odors caused by drying the precipitate, that much of it is now raised by steam-power, by means of an endless-bucket pump to a wooden conduit several feet above the ground, whence it is distributed to various parts of the farm. It is of the consistency of soft mud, and contains eighty per cent. of water. After being distributed over the land, about a foot deep, it is dug in by hand-labor. This process is carried out in each plot of land, once in three years. It is a costly manure, as

so much labor is required to handle it, but it is said to improve the land in a high degree.

4. In the first of the series of settling-tanks (there are two sets, to be used alternately), the heaviest part of the suspended matter is precipitated by lime. As soon as this becomes two feet deep, about once in two weeks, the fluid is run off, the tank is closed, the mud is allowed to dry, and is then removed by means of shovels. This process is attended with very offensive smells.

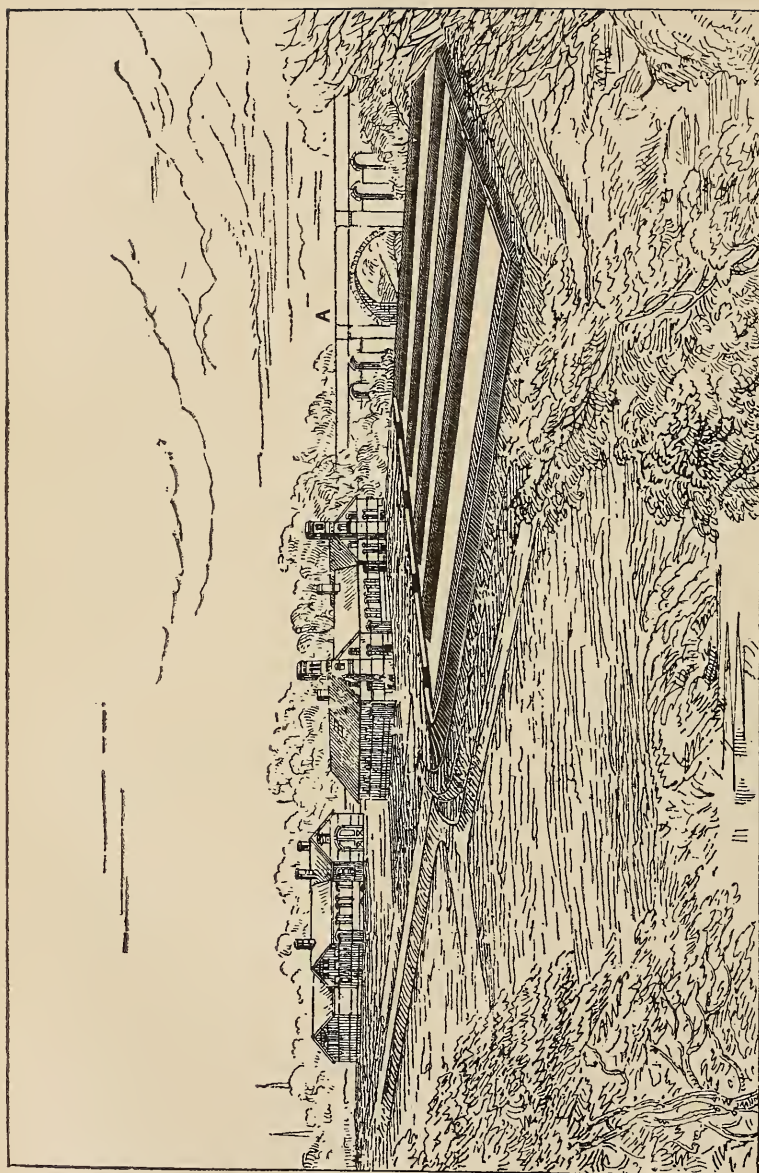
5. A portion of the last-named matter is kiln-dried, and made into cement by Scott's process. This is certainly the best method of disposing of sewer-sludge at present in use. The works at Birmingham are on a small scale, and were constructed to show that good cement may be made in this way without great loss. The large amount of iron in the sewage renders the addition of a large amount of lime necessary. Three tons of cement are made each week, and it sells readily for seven shillings a barrel. The loss, in the whole operation of converting the sludge into cement, is fifteen per cent.

Nearly 17,000,000 gallons of sewage (dry-weather flow) are pumped each day by steam and treated with from twelve to thirteen tons of lime. The workmen state that they become accustomed in a short time to the bad odors. They work in the open air so much of the time that they are in good health.

Coventry.

This is a town of 20,000 inhabitants, with a daily dry-weather flow of 800,000 gallons of sewage. The precipitating process now used is one patented by Dr. Anderson, differing only in unimportant details from the methods which have been made the bases of experiments in France, England and Germany. A cheap shale, found in the immediate neighborhood, is treated with crude sulphuric acid, by which sulphate of alumina is obtained at a low price.

The floating matters in the sewage are removed by an ingenious revolving screen, invented by Mr. Baldwin Latham, and worked by the motive-power of the flowing sewage. A simple grating, cleared occasionally by means of an iron rake, is cheaper, and fully as serviceable.



THE WORKS OF THE GENERAL SEWAGE AND MANURE COMPANY, AT COVENTRY.

From a photograph of the Company's circular. A represents a railroad bridge.

The sewage is then mixed with the sulphate of alumina (four tons to each 1,000,000 gallons) in a large tank, from which it flows to a second tank, where it is again mixed with lime (one ton to each 1,000,000 gallons*). Sulphate of lime is thus formed, setting free the alumina, which is precipitated. Sixteen grains of lime pass out in each gallon of effluent.

Two tanks, of two compartments each, are used alternately for settling; they are each one hundred and fifty feet long, fifty feet wide, and ten feet deep, and have a capacity of 500,000 gallons. After standing about a week, during which time there is a constant overflow, the supernatant fluid remaining is passed off, and the sludge is brushed through an underground passage into the building where it is pumped and dried by artificial heat under cover; an apparently inoffensive, but costly, process.

Seventeen tons of the "manure" are precipitated daily, at a cost of about ten shillings a ton; its commercial value, as shown already, is about two shillings a ton. The company places on it a theoretical value of £2 a ton, and is now engaged in "fortifying" it with other manure, by which addition they say it will be worth £5.

The effluent, as passed from the tanks, and before putrefaction has begun, is nearly clear. It does not satisfy the Rivers Pollution Commission, and much of it is purified by irrigation before running into the river. The stream into which it is discharged is so polluted from other sources, as to resemble, in appearance and smell, a common open sewer.

The freedom of the works from offensive odors is got at great cost to the city. The effluent requires purification before it can be allowed to run into the river, and the manure, up to last September, had not found purchasers. The city pays to the company in charge of the works a large subsidy, beside losing the interest on the original cost of the works.

The company has had nothing to pay towards the construction of the works, and, beside receiving the subsidy from the city, receives all the revenue from the sale of "manure."

A plan of the works is given.

* Fifty thousand gallons of sewage produce about one ton of precipitate.

Edinburgh.

Irrigation has been carried on for almost two centuries by the use of brooks, which have been made to convey the sewage of certain parts of the city. There are at present four farms: One, the famous Craigentenny meadows, on the Foul Burn, of two hundred and fifty acres, east of Edinburgh, and lying close to the beach; a second, to the west, on the Lochrine Burn, of ninety acres; to the south, Jordan Burn irrigates eleven acres; on the northerly boundary of the city five acres are irrigated by the Broughton Burn. Irrigation on all those farms was formerly carried on in the rudest manner possible. The land was fairly drenched with sewage, 20,000 to 100,000 tons* being used, in some cases, on a single acre in one year. The effect was, that Edinburgh was "surrounded by these artificial swamps, which at all times emit odors of not the most agreeable description."† At the present time, the method of irrigation pursued is much improved, but still not entirely free from objectionable features.

The sewage is distributed by gravitation through open trenches, and is flooded over each lot of land for a few hours once in nine days;‡ it is quickly absorbed, without being the source of offensive smells. The main conduits are sometimes, at least, in a foul condition; their sides are exposed to the air as the level of the sewage falls, and, being simply dug in the earth, and not always thoroughly cleaned, they retain a large mass of decomposing organic matter.

Only grass§ is raised on these farms, as it is the only crop which thrives under such neglect, and is at the same time highly remunerative. Four crops are raised each year.

* Five thousand tons is the amount considered best by Mr. Hope and other authorities.

† Report on the Sanitary Condition of the City of Edinburgh, by Henry D. Littlejohn, M. D., F. R. C. S. E., medical officer of health for the city. 1866.

‡ More or less; depending upon the weather.

§ Italian rye-grass, a biennial plant, has proved almost a necessity to the sewage farmer. It is capable of receiving an immense amount of sewage without injury, and is admirably adapted to receive any surplus on nearly all occasions when it is not needed for vegetables and root-crops. A cut of the plant is given, which I have copied from Fegebeutel. Its cultivation has been so successful in England, that it has been introduced in France and Germany on the sewage-farms.



Italian Rye-grass.

Lolium italicum.

The demand for it, sold in the green state, is of course limited, and is now fully supplied, although so small a part of the sewage—less than one-fourth—is utilized.

The land, under this treatment, has increased enormously in fertility. The rents of some parts have risen from 5s. to £20 an acre for a single year, while individual acres bring as much as £40. Little has been done in the way of subsoil-drainage, levelling, etc.

The farms are carried on by private owners, who have vested rights in the sewage, for which they pay nothing. The cost of managing them is small, and the profits are very great. The grass is sold readily in limited quantities, most of the dairymen in Edinburgh being supplied with it; but many times the quantity required to supply the market could be readily raised if all the sewage were used.

During the winter, and during wet seasons of summer, the sewage is discharged without use, and therefore without the partial purification which it gets in dry and warm weather. In a sanitary point of view, therefore, this method of using the sewage is far from satisfactory. In spite of this, however, in all these years no absolutely ill effects have been traced to this cause. People in the immediate vicinity of the farms, and especially a regiment of infantry in barracks, are annoyed by bad smells, but they have not suffered in health. In fact, when the cholera was raging in the city, not a single case occurred near the irrigated meadows. Dr. Littlejohn says in regard to this matter,* that it has been plausibly conjectured that the insalubrity of the easterly winds depends largely on contamination in passing over the irrigated meadows. He says: "At any rate, a city surrounded by swamps cannot be regarded as in a sound sanitary condition."

No one can inspect these farms without seeing that the irrigation is carried on in a very cheap and unsatisfactory way; and there is no control over the matter by the authorities.† If there are any influences injurious to health arising from the farms near Edinburgh, as there may be, they can easily be

* Report, p. 90.

† In 1839 the city authorities tried to stop this sewage-irrigation, but they could not do so, as the owners of the land claimed enormous sums for damages in case they should be deprived of their privileges.

remedied with care. The odors from them were found by the writer, last September, to be offensive, though not intensely so.

West Derby.

Three years ago, the parish of West Derby, adjacent to Liverpool, purposed building sewers, with outlets into the river Mersey, at an estimated cost of £30,000. Being threatened with an injunction, they decided to carry their mains farther, buy a farm, and irrigate. The cost has been as follows :—

For construction of sewers, ...	£42,335
two hundred acres of land, ...	34,000
levelling, constructing conduits, purchase of stock, etc., ...	24,000
tanks (estimated), ...	4,000

The running expenses are estimated at £3,000 a year. The crops find a ready sale, and it is thought that, under good management, they will yield an annual income of £4,000.

As far as sanitary requirements and engineering skill are concerned, the farm is a model one. It was laid out by Mr. W. Hope. The land was rather heavy and rough, and large sums were necessarily spent in its preparation. Drainage-pipes are laid at a depth of four feet and a half, and twelve feet apart. The sewage is distributed by gravitation through open cement carriers, and from them by shallow trenches dug in the earth. The latter are thirty feet apart. The land is graded from the mains so as to have a fall of one in 150.

The sewage, purified by the vegetation and the action of the soil, mingles with the ground-water, and passes out through the drains, a clear, sparkling stream, into the river Alt. Large settling-tanks are in process of construction, partly to serve as reservoirs over Sundays, and partly to deposit the solid matters, which are considered of little value. There is a difference of opinion as to the utility of these tanks. So far as the sewage is thereby retained long enough for putrefaction to begin, by just so much is its value lessened.

Carrots, turnips, beets, grass, rye-grass, etc., are raised on the land irrigated during summer. The plots which are used

in winter-irrigation are planted in cereals, and are not irrigated during the warm months. Seven crops of rye-grass are raised each year, the first being cut in January, the last in December.

The land has increased in value, much of it that was very poor now yielding good crops.

There is no complaint of bad odors, and in August it was found absolutely free from anything of the kind. There is a slight fresh-sewage smell close to the conduits.

The main carriers for the sewage are of cement, as represented in Fig. I, page 340 of this Report; the laterals are shallow trenches in the earth, and from each two contiguous branches the land is so graded as to slope gradually to the central point between them, at a fall of about one in fifty.

Crewe.

The farm, two miles distant from the town, disposes of the sewage of 25,000 people on 300 acres. It was admirably laid out by Mr. Hope, and is well managed and free from offensive odors. The sewage is pumped before distribution, and the annual deficit in the account is a considerable one. The crops are sold readily. The produce of a single acre of oats sold, late in August, for £20, at auction. The soil is of the toughest clay; much of it required burning before crops could be raised on it to advantage. The subsoil-drains are four feet deep, but experience has shown that the sewage runs off too rapidly, and that it would be better, in such a soil, to place them two feet deeper still. Mr. Hope has here shown that any soil whatever may be made capable of purifying sewage by irrigation.

Romford.

This farm was visited, in 1870, by Dr. Bowditch, and was found absolutely free from offensive odors. The same fine crops which he observed are still found there. "Carrots, four and a half inches in diameter, and a foot long; mangolds, twenty-nine and thirty-six inches in diameter, and pressing up, like huge monsters, from the ground; cabbages, huge and compact; immense beds of rich and firm cauliflowers; potatoes, eight or nine inches long, and weighing, at times, two

pounds; hay of delicate fibre, and eagerly sought for by cattle, can be raised in three crops annually, and, in quantity, five acres produced as much as twenty-five treated by the usual former method." *

Mr. Hope has given his personal attention to irrigation here, and the results have been eminently satisfactory in every way, except that they have not been profitable. He considers this fact to be due to causes which can be removed. The scientific experiments, of great value, which have been conducted here, are to be found in the proceedings of the British Association for the Advancement of Science for the last seven years. In three years about 168,000 pounds of nitrogen were distributed on the farm, of which it was estimated that nearly 58,200 pounds, or 34.6 per cent., were recovered in the crops; of the remainder, some escaped in the effluent water, chiefly in the form of nitrates and nitrites, and some were stored in the soil.

The following tables (see pp. 360-372) are quoted from the sixth report of the committee on the treatment and utilization of sewage† at the meeting of the association in 1874, as they are of great practical interest.

Croydon.

Under the Public Health Act of 1848, the authorities of Croydon built extensive sewers, and connected water-closets with them, as the law compelled them to do. As the river Wandle, into which they discharged their sewage, is a mere brook, ankle-deep in some places in summer, it soon became so polluted as to give occasion to frequent complaints. The various deodorizers, precipitants, etc., were then tried, and proved to be failures. At last, irrigation was begun, in an experimental way, as there was absolutely no experience in any part of the world to serve as a guide.‡

In 1853 there was such a violent outbreak of fever as to

* Second Report of the State Board of Health, p. 241.

† This committee consisted of Richard B. Grantham, C. E., F. G. S., chairman; F. J. Bramwell, C. E., F. R. S.; Prof. W. H. Corfield, M. A., M. D., (Oxon.); J. H. Gilbert, Ph. D., F. R. S., F. C. S.; W. Hope, V. C.; Prof. A. W. Williamson, Ph. D., F. R. S., F. C. S.

‡ Even then the irrigation at Edinburgh was not considered satisfactory, from a sanitary point of view.

call for investigation by parliamentary commissions.* The disease was found to be due to defective sanitary arrangements, by which, the sewer-gases escaped into the houses. This difficulty was remedied,† and the town was unusually free from disease until the epidemic of 1875, which was due to the pollution of drinking-water by sewer-gases, as already described.‡

When the town was compelled by chancery-injunction to purify its sewage so as not to make a common sewer of the river Wandle, the first attempts at irrigation were attended with many failures, and at times a nuisance was probably caused. Experience has, however, remedied all these defects; the farm is free from odors, and there has not been a single complaint for several years, although there are many people living in the immediate vicinity, and the public road passes directly through the farm. Six houses, each renting at from £125 to £150 a year, have been built within a few rods of the irrigated land. A large orphan asylum is close to one boundary; and, a fourth of a mile distant, twenty-five cottages have been built. In all these places, typhoid fever is almost unknown. The workmen and the occupants of the cottages use, by preference, the purified sewage for domestic purposes.§ It looks clear and sparkling,|| has no especial taste, more than satisfies the conditions of the Rivers Pollution Commission, and the brook into which it runs is literally filled with minute fish. The water is so clear and free from putrefactive ingredients, that a wealthy gentleman, living near by, has built a conduit, at his own expense, to have it conveyed through his grounds.

Part of the land was originally bought for £160 an acre;

* Five reports were published: 1. By T. Southwood Smith, M. D., and John Sutherland, M. D. 2. By R. D. Grainger and Henry Austin. 3. By Neil Arnott, M. D., and Thomas Page, C. E. 4. By Henry Austin, Consulting Engineer to the General Board of Health. 5. By Thomas Wicksteed, C. E.

† There was no evidence that the irrigation with sewage was even partly the source of the outbreak.

‡ See page 293.

§ Of course this use of the water is not recommended by the health authorities, but no harm has been known to come from it at Croydon.

|| A bottle of it, kept for a year by Dr. Carpenter, remained clear and odorless. The effluent from the sewage-farm at Aldershot is also extensively used for drinking, and is preferred to any other that can be got.

[See p. 373.

TABLE I.—Breton's Sewage-Farm. *Statement showing Crops grown from March 25, 1873, to March 24, 1874.*

	No. of beds (inclusive).	Acreage.	Crop.	Date when sown or planted.	Date when cut or gathered.	PRODUCE.		Remarks.
						Total—tons.	Per acre—tons.	
Plot A,	1 to 29, .	9.8	Cabbage, .	Oct., 1872, .	April to June, 1873.	124.74	12.7	
	1 to 29, .	9.8	Barley, .	June, 1873, .	Oct., 1873, .	13.52	1.4	Including 6.94 tons straw.
	1 to 29, .	9.8	Italian rye-grass, .	" 1873, .	Dec., 1873, and Jan., 1874.	32.63	3.3	Sown the day after the barley; once cut.
Total, .	. . .	9.8	. . .	. . .	. . .	170.89	17.4	The whole plot under crop at the end of the year. (Italian rye-grass.)
Plot B,	8 to 16, .	4.20	Cabbage, .	Sept., 1872, .	May to July, 1873.	92.92	22.1	One-third consumed by cattle, waste, &c.
	1 to 5, .	2.43	Oats, .	Mar., 1873, .	Aug., 1873, .	6.58	2.7	4.33 tons straw.
	6 to 7, .	.96	Wheat, .	" 1873, .	" 1873, .	15.44	2.8	9.54 tons straw.
	17 to 26, .	4.54	Wheat, .	" 1873, .	" 1873, .			
	1 to 3, .	1.47	Sprouting broccoli, .	Aug., 1873, .	Mar., 1874, .	5.52	3.8	One-third ploughed in or consumed by cattle.
	4, 5, .	.97	Brussels sprouts, .	" 1873, .	" 1874, .	0.75	0.8	
	6 to 8, .	1.43	Cabbage, .	" 1873, .	" 1874, .	2.11	1.5	One-half ploughed in or consumed by cattle.

Plot B,	8, .	.44	Peas, . . .	May, 1873, .	Aug. and Sept., 1873.	1.27	2.9	One ton straw.
	9 to 14, .	2.80	Cabbage-plants, .	Aug., 1873, .	Sept. and Nov., 1873.	11.67	4.2	Plants replanted on farm.
	15, 16, .	.92	Turnips, . . .	" 1873, .	Oct. to Dec., 1873.	13.30	14.5	
	17 to 26, .	4.54	Cabbage, . . .	Oct., 1873, .	-	-	-	Crop remained March, 1874.
	11 to 16, .	2.78	Peas, . . .	Mar., 1874, .	-	-	-	Crop remained March, 1874.
	1 to 10, .	4.80	Fallow, . . .	-	-	-	-	
Total, .	. . .	12.12				149.56	12.3	Part of plot under crop at end of year.
Plot C,	All, .	1.97	Wheat, . . .	Mar., 1873, .	Aug., 1873, .	5.24	2.7	3.47 tons straw.
	All, .	1.97	Cabbage, . . .	Oct., 1873, .	-	-	-	Crop remained March, 1874.
Total, .	. . .	1.97				5.24	2.7	Plot all under crop (cabbage) at the end of the year.
Plot D,	All, .	6.93	Italian rye-grass, .	Aug., 1872, .	July to Dec., 1873.	452.95	65.4	Grass ploughed in. Plot fallow, Mar. 25, 1874; mangolds sown afterwards.
Plot E,	1 to 22, .	5.76	Cabbage, . . .	Oct., 1872, .	May and June, 1873.	85.42	14.8	One-fourth ploughed in or carted to cattle.
	1 to 16, .	4.35	Cabbage, . . .	June and July, 1873.	Sept. to Nov., 1873.	73.07	16.8	One-fourth ploughed in or carted to cattle.
	17, . .	.24	Cauliflowers, . .	June, 1873, .	Oct., 1873, .	1.25	5.2	
	18, . .	.24	Sprouting broccoii, .	" 1873, .	Jan. and Feb., 1874.	2.58	10.7	One-half leaves &c., consumed by cattle or ploughed in.

TABLE I.—*Breton's Sewage-Farm*—Continued.

	No. of beds (inclusive).	Acreage.	Crop.	Date when sown or planted.	Date when cut or gathered.	PRODUCE.		Remarks.
						Total—tons.	Per acre—tons.	
Plot E,	Part 19, .	.12	Onions, .	June, 1873, .	Oct. and Nov., 1873.	2.25	18.7	
	" 19, .	.12	Lettuce, .	" 1873, .	July, 1873, .	1.50	12.5	
	" 19, .	.12	Cabbage-plants, .	Aug., 1873, .	Oct., 1873, .	2.43	20.2	
	20 to 22, .	.69	Mangolds, .	May and June, 1873.	Nov., 1873, .	12.25	17.9	
	1 to 22, .	5.76	Wheat, .	Mar., 1874, .	-	-	-	Crop remained March, 1874.
Total, .		5.76				180.75	31.4	Plot all under crop of spring-wheat at end of year.
Plot F,	12 to 18, .	1.48	Strawberries, .	Mar. to Nov., 1872.	June to July, 1873.	0.09	0.06	
	1 to 6, .	1.27	Oats, .	Apr., 1873, .	Aug., 1873, .	4.69	3.7	2.89 tons straw.
	7 to 11, .	1.06	Barley, .	" 1873, .	" 1873, .	2.71	2.5	1.73 tons straw.
	15 to 18, .	.85	Cabbage, .	Sept., 1873, .	Mar., 1873, .	1.20	1.4	Seed-bed.
	1 to 14, .	2.97	Wheat, .	Feb., 1874, .	-	-	-	Crop remained March, 1874.
Total, .		3.82				8.69	2.3	Part of plot under crop at end [of year.

Plot G,	5 to 10, 17 to 22.	2.82	Cabbage,	Sept. and Oct., 1872.	May to July, 1873.	51.87	18.4	One-third carted to cattle or ploughed in.
	1 to 4,	.94	Carrots,	Mar., 1873,	June and July, 1873.	4.28	4.6	
	11, 12,	.47	Onions,	Sept., 1872,	June, 1873,	0.61	1.3	The produce of one bed only; the other failed.
	11,	.23	Hardy green plants,	May, 1873,	July, 1873,	7.07	30.7	
	13, 15, 16,	.70	Spinach,	" 1873,	May to July, 1873.	8.02	11.4	One-tenth only sent to market; remainder given to cattle or ploughed in.
	1 to 8, 11, 12.	2.35	Mangolds,	July, 1873,	Nov., 1873,	44.10	18.8	One-sixth tops, &c.
	13 to 16,	.94	Turnips,	" 1873,	Sept. to Dec., 1873.	26.60	28.3	
	9, 10, 17 to 20.	1.41	Sprouting broccoli,	" 1873,	Mar., 1874,	8.74	6.2	
	21,	.23	Spinach,	" 1873,	Aug., 1873,	2.25	9.8	
	$\frac{1}{2}$ 22,	.12	Lettuce,	May, 1873,	July, 1873,	1.12	9.3	
	$\frac{1}{2}$ 22,	.12	Cabbage,	" 1873,	Aug., 1873,	2.65	22.1	
	$\frac{1}{2}$ 22,	.12	Hardy greens,	July, 1873,	Nov., 1873,	2.00	16.7	
	1 to 8, 11, 12.	2.35	Cabbage,	Nov., 1873,	-	-	-	Crop remains.
	9, 10, 13 to 16, 17 to 22.	2.82	Fallow,	-	-	-	-	
Total,	.	5.17	.	.	.	159.31	30.8	Part under crop at end of year.

TABLE I.—*Breton's Sewage-Farm*—Continued.

	No. of beds (inclusive).	Acreage.	Crop.	Date when sown or planted.	Date when cut or gathered.	PRODUCE.		Remarks.
						Total—tons.	Per acre—tons.	
Plot H,	1 to 17½	4.11	Onions, . . .	Feb. and Mar., 1873.	July to Sept., 1873.	36.12	8.8	Crop failed.
	17½ to 24,	2.29	Onions, . . .	Feb. and Mar., 1873.	—	—	—	
	17½ to 19,	.76	Hardy green plants,	May, 1873, .	July, 1873, .	4.28	5.6	
	17½ to 19,	.76	Cabbage, . . .	July, 1873, .	Oct. and Nov., 1873.	12.37	16.3	
	20 to 24,	1.53	French beans, .	May, 1873, .	July to Sept., 1873.	2.52	1.7	
	1 to 5,	1.08	Hardy greens, .	Aug., 1873, .	Dec., 1873, .	8.29	7.7	
	6, 7, .	.47	Spinach, . . .	" 1873, .	Oct., 1873, to Mar., 1874.	0.67	1.4	
	8 to 24,	4.86	Cabbage, . . .	Oct. and Nov., 1873.	—	—	—	
Total, .	1 to 5,	1.08	Fallow, . . .	—	—	—	—	This crop still remains.
	. . .	6.40	. . .	. . .	. . .	64.25	10.0	This crop still remains.
	. . .		. . .	. . .	. . .			Part under crop at end of year.
Plot I,	1 to 3½	1.30	Onions, . . .	Apr., 1873, .	Sept. and Oct., 1873.	8.43	6.5	
	3½ to 6,	.94	Carrots, . . .	" 1873, .	Aug., 1873, .	4.69	5.0	

Plot I,	7 to 12, 13 to 16, 17, 18,	2.29 1.56 .58	Savoys, . Carrots, . Cabbage,	June, 1873, . Apr., 1873, . June, 1873, .	Dec., 1873, to Feb., 1874. Aug., 1873, . Aug. to Oct., 1873.	26.30 14.70 10.87	11.5 9.4 18.7	One-fifth to cattle or ploughed in.
	1 to 16, 17, 18,	6.09 .58	Wheat, . Cabbage,	Feb., 1874, . Nov., 1873, .	- -	- -	- -	Crop remains. Crop remains.
Total, .	. . .	6.67	. . .	. . .	. . .	64.99	9.7	Plot all under crop at end of year.
Plot K,	All, .	4.44	Italian rye-grass,	Sept., 1872, .	Mar., 1873, to Jan., 1874.	277.06	62.4	Crop remains; cut eight times in year.
Plot L,	Part, .	1.22	Mangolds, .	July, 1873, .	Nov., 1873, .	25.05	20.5	
	Part, .	.66	Hardy greens,	" 1873, .	Dec., 1873, .	3.23	4.9	
	Part, .	1.00	Savoys, .	" 1873, .	Feb., 1874, .	4.38	4.4	
Total, .	. . .	2.88	. . .	. . .	. . .	32.66	11.4	Plot all fallow at end of year.
Plot M,	All, .	3.17	Italian rye-grass,	Sept., 1872, .	Mar., 1873, to Jan., 1874.	182.49	57.5	Crop remains; cut eight times in year.
Plot N,	1 to 16,	4.15	Italian rye-grass,	Mar. and May, 1872.	Mar. to May, 1873.	140.96	34.0	Grass ploughed in May, 1873.

TABLE I.—*Bretton's Sewage-Farm*—Continued.

	No. of beds (inclusive).	Acreage.	Crop.	Date when sown or planted.	Date when cut or gathered.	Produce.		Remarks.
						Total—tons.	Per acre—tons.	
Plot N,	1 to 16, .	4.15	Barley, . . .	June, 1873, .	Sept., 1873, .	4.74	1.1	Including straw, 3.47 tons.
	1 to 16, .	4.15	Italian rye-grass, .	" 1873, .	Nov., 1873, to Mar., 1874.	26.74	6.4	This grass was set with the barley, and still remains.
Total, .	. . .	4.15	. . .	. . .	. . .	172.44	41.5	Plot all under crop at end of year.
Plot O,	All, . .	5.92	Cabbage, . . .	Sept., 1872, .	Apr. to June, 1873.	85.89	14.5	
	1 to 8, 10 to 17, .	5.55	Hardy greens, . .	July, 1873, .	Oct. to Dec., 1873.	69.86	12.6	
	9, . . .	.37	Cabbage-plants, . .	" 1873, .	Aug. and Sept., 1873.	2.33	6.3	Transplanted.
	9, . . .	.37	Hardy greens, . .	Oct., 1873, .	Jan., 1874, .	.71	1.9	
	1 to 17, .	5.92	Onions, . . .	Mar., 1874, .	—	—	—	Crop remains.
Total, .	. . .	5.92	. . .	. . .	. . .	158.79	26.8	Plot all under crop at end of year.
Plot P,	All, . .	3.50	Wheat, . . .	Mar., 1873, .	Aug., 1873, .	8.68	2.5	6.07 tons straw.
	All, . .	3.50	Hardy greens, . .	Aug., 1873, .	Jan. and Feb., 1874.	10.82	3.1	
	All, . .	3.50	Wheat, . . .	Feb., 1874, .	—	—	—	Crop remains.
Total, .	. . .	3.50	. . .	. . .	. . .	19.50	5.6	Plot all under crop at end of [year.

Plot Q,	1 to 10,	.	1.04	Cabbage,	.	Oct., 1872,	.	Apr., 1873,	.	2.00	1.9	
	1 to 20,	.	2.34	Mangolds,	.	May, 1873,	.	Nov., 1873,	.	38.00	16.2	
	1 to 20,	.	2.34	Wheat,	.	Feb., 1874,	.	-		-	-	Crop remains.
Total,	.	.	2.34	.	.	.	.	.	.	40.00	18.1	Plot all under crop at end of year.
Plot R,	Part,	.	2.40	Mangolds,	.	Apr., 1873,	.	Oct. and Nov., 1873,	.	45.32	18.8	
	Part,	.	2.40	Wheat,	.	Feb., 1874,	.	-		-	-	Crop remains.
	Part,	.	.12	Oziers,	.	Jan., 1873,	.	Cleared Nov., 1873,	.	.50	4.1	Oziers used for bunch'g greens, etc.
Total,	.	.	2.52	.	.	.	.	.	.	45.82	18.2	Plot nearly all under crop at end of year.
Plot S,	All,	.	.22	Rhubarb,	.	Feb., 1873,	.	Feb. and Mar., 1874,	.	.17	.8	Crop remains.
Plot U,	All,	.	2.53	Wheat,	.	Mar., 1873,	.	Aug., 1873,	.	7.05	2.8	4.62 tons straw.
	All,	.	2.53	Hardy greens,	.	Aug., 1873,	.	Jan. and Feb., 1874,	.	5.62	2.2	
	All,	.	2.53	Wheat,	.	Feb., 1874,	.	-		-	-	Crop remains.
Total,	.	.	2.53	.	.	.	.	.	.	12.67	5.0	Plot all under crop at end of [year.

TABLE I.—*Breton's Sewage-Farm*—Continued.

	No. of beds (inclusive).	Acreage.	Crop.	Date when sown or planted.	Date when cut or gathered.	PRODUCE.		Remarks.
						Total—tons.	Per acre—tons.	
Plot V,	Part, .	2.93	Cabbage, .	Oct., 1872, .	May to July, 1873. .	58.48	20.0	This crop was nearly all destroyed by an accident with the sewage. Crop remains.
	Part, .	3.00	Scarlet beans, .	May, 1873, .	Aug. and Sept., 1873. .	.50	.2	
	All, .	5.93	Wheat, .	Mar., 1874, .	-	-	-	
Total, .	. . .	5.93	. . .	. . .	. . .	58.98	9.9	Plot all under spring-wheat at end of year.
Plot W,	All, .	2.75	Wheat, .	Mar., 1873, .	Aug., 1873, .	6.61	2.4	Straw, 4.62 tons.
	All, .	2.75	Hardy greens, .	Sept. and Oct., 1873. .	Feb. to Mar., 1874. .	5.12	1.9	Crop remains.
	All, .	2.75	Wheat, .	Mar., 1874, .	-	-	-	
Total, .	. . .	2.75	. . .	. . .	. . .	11.73	4.3	Plot all under spring-wheat at end of year.
Plot X,	All, .	3.86	Wheat, .	Mar., 1873, .	Sept., 1873, .	8.99	2.3	Straw, 6.36 tons.
	All, .	3.86	Wheat, .	Mar., 1874, .	-	-	-	Crop remains.
Total, .	. . .	3.86	. . .	. . .	. . .	8.99	2.3	Plot all under spring-wheat at [end of year.

Plot Y,	-	5.60	Hay, Grass-meadow,	Permanent grass, Permanent grass,	July, 1873, July to Nov., 1873.	15.50 60.00	2.8 10.7	One cutting only. Plot used for grazing from July to Novem- ber, 1873. Quantity grazed computed.
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NOTE.—The boundaries of plots Q and V have been rearranged since last year.

TABLE II.—*Breton's Sewage-Farm. Season 1873-74. Summary of Cropping Return.*

Plot.	Acreage.	CROPS.	PRODUCE.	
			Total— tons.	Per acre —tons.
A,	9.80	Cabbage, barley, and Italian rye-grass, .	170.89	17.4
B	12.12	Cabbage, oats, wheat, sprouting broccoli, Brussels sprouts, peas, cabbage-plants, and turnips.	149.56	12.3
C,	1.97	Wheat, ...	5.24	2.7
D,	6.93	Italian rye-grass, ...	452.95	65.4
E,	5.76	Cabbage, cauliflowers, sprouting broccoli, onions, lettuce, cabbage-plants, and mangolds.	180.75	31.4
F,	3.82	Strawberries, oats, barley, and cabbage, .	8.69	2.3
G,	5.17	Cabbage, carrots, onions, hardy green plants, spinach, mangolds, turnips, sprouting broccoli, lettuce, and hardy greens.	159.31	30.8
H,	6.40	Onions, hardy green plants, French beans, cabbage, hardy greens, and spinach.	64.25	10.0
I,	6.67	Onions, carrots, savoys, and cabbage, .	64.99	9.7
K,	4.44	Italian rye-grass, ...	277.06	62.4
L,	2.88	Mangolds, hardy greens, and savoys, .	32.66	11.4
M,	3.17	Italian rye-grass, ...	182.49	57.5
N,	4.15	Italian rye-grass and barley, ...	172.44	41.5
O,	5.92	Cabbage, hardy greens, and cabbage-plants,	158.79	26.8
P,	3.50	Wheat and hardy greens, ...	19.50	5.6
Q,	2.34	Cabbage and mangolds, ...	40.00	18.1
R,	2.52	Mangolds and oziers, ...	45.82	18.2
S,	.22	Rhubarb, ...	.17	.8
U,	2.53	Wheat and hardy greens, ...	12.67	5.0
V,	5.93	Cabbage and scarlet beans, ...	58.98	9.9
W,	2.75	Wheat and hardy greens, ...	11.73	4.3
X,	3.86	Wheat, ...	8.99	2.3
Y,	5.60	Hay and meadow-grass, ...	75.50	13.5
	108.45		2,353.43	21.7

TABLE III.—*Breton's Sewage-Farm. Summary of Crops gathered from March 25, 1873, to March 24, 1874, showing the quantity of each kind of Produce and Nitrogen contained therein.*

CROPS.	Total Acreage of each description of Crop.	PRODUCE OF EACH CROP.		NITROGEN ESTIMATED IN CROPS.		
		Total tons.	Tons per Acre.	Per cent.	Total lbs.	Per acre. lbs.
Italian rye-grass, . . . }	28.49	1,112.83	39.1	0.54	13,461	472
Grass, meadow, . . . }	5.60	60.00	10.7	0.54	726	130
Hay, ... }		15.50	2.8	2.00	694	124
Oziers, ...	0.12	0.50	4.1	—	—	—
Cabbage, ...	43.85	620.02	14.1	0.25	3,472	79
Hardy greens, . . .	17.55	117.00	6.7	0.25	655	37
Savoys, ...	3.29	30.68	9.3	0.25	172	52
Brussels spr'ts, . .	0.97	0.75	0.8	0.25	4	4.1
Broccoli, ...	3.12	16.84	5.4	0.25	94	30
Cauliflowers, . . .	0.24	1.25	5.2	0.25	7	29
Beans (French and runner), }	4.53	3.02*	0.7*	0.375	25	5.5
Spinach, ...	1.40	10.94	7.8	0.25	61	44
Peas, ...	0.44	{ .27† 1.00‡	{ .6 2.3	{ 3.40 0.80 }	62	141
Carrots, ...	3.44	23.67	6.9	0.20	106	31
Turnips, ...	1.86	39.90	21.5	0.18	161	87
Lettuce, ...	0.24	2.62	10.9	0.25	15	63
Mangolds, ...	9.00	164.72	18.3	0.25	922	102
Onions, ...	6.00	47.41	7.9	0.22	234	39
Oats, ...	3.70	{ 4.05§ 7.22‡	{ 1.1 1.9	{ 2.0 0.6 }	278	75
Barley, ...	15.01	{ 8.83§ 12.14‡	{ 0.6 0.8	{ 1.6 0.5 }	452	30
Wheat, ...	20.11	{ 17.33§ 34.68‡	{ 0.8 1.7	{ 1.8 0.6 }	1,165	58
Strawberries, . . .	1.48	0.09	0.06	0.1	—	—
Rhubarb, ...	0.22	0.17	0.8	—	—	—
Total, ...	170.66	2,353.43	13.8	—	22,766	133.4

* Crop nearly all destroyed by accident.

† Peas.

‡ Straw.

§ Grain.

TABLE IV.—*Breton's Sewage-Farm. Statement of Land in Crop and Land lying Fallow on March 24, 1874.*

PLOT.	Acreage.	Area in Crop, acres.	Area fallow, acres.	PLOT.	Acreage.	Area in Crop, acres.	Area fallow, acres.
A, . .	9.80	9.80	—	N, . .	4.15	4.15	—
B, . .	12.12	7.32	4.80	O, . .	5.92	5.92	—
C, . .	1.97	1.97	—	P, . .	3.50	3.50	—
D, . .	6.93	—	6.93	Q, . .	2.34	2.34	—
E, . .	5.76	5.76	—	R, . .	2.52	2.52	—
F, . .	3.82	2.97	.85	S, . .	.22	.22	—
G, . .	5.17	2.35	2.82	U, . .	2.53	2.53	—
H, . .	6.40	5.32	1.08	V, . .	5.93	5.93	—
I, . .	6.67	6.67	—	W, . .	2.75	2.75	—
K, . .	4.44	4.44	—	X, . .	3.86	3.86	—
L, . .	2.87	—	2.87	Y, . .	5.60	5.60	—
M, . .	3.17	3.17	—	Total, .	108.44	89.09	19.35

Comparison.

DATE.	In Crop, acres.	Fallow, acres.	Total Acres.
March 24, 1872, ...	40.49	63.39	103.88
“ 24, 1873, ...	87.62*	19.93	107.55
“ 24, 1874, ...	89.09*	19.35	108.44

* In regard to this comparison, it should be stated that the area described as “in crop” comprises land sown with spring-wheat.

On March 24, 1873, about 22½ acres.

“ 24, 1874, “ 38 “

There was no wheat in on March 24, 1872. The spring wheat being sown in March, these figures should be borne in mind in comparing the above.

the rest is leased at from £10 to £12 an acre, per annum. Under such circumstances, and considering the fact that the farm is carried on by a corporation and not by an individual, it is natural to expect that it would not be profitable. The loss is slight, however. Five hundred acres are irrigated by gravitation, with a daily flow of about 2,000,000 gallons of sewage from a population of 60,000 persons. The subsoil is loose gravel, so that deep drainage has not been necessary. The whole cost of preparing the land for irrigation has been perhaps greater than was necessary. The main conduits for the sewage are simple trenches in the earth. They answer every purpose, as they are cleaned frequently.

The crops raised look in admirable condition. Some of the wheat, hay, turnips, cabbages, etc., are splendid specimens. The crops are sold readily. The Italian rye-grass is irrigated for from twenty-four to forty-eight hours each week, the vegetables not oftener than once in two, or, at times, four or even six weeks, if the season is wet. If possible, no particular crop is irrigated within a week previous to the time of its being harvested. This rule, however, is not always adhered to in the case of the rye-grass, which apparently has a capacity for being irrigated almost constantly for some time, if it is necessary to do so in order to get rid of the sewage.

A large part of the great success of this farm is undoubtedly due to the careful attention given to it by Dr. Alfred Carpenter, chairman of the local board; but the small pecuniary deficit, in spite of the enormous rent, is due to the fact that it has been made in large part a dairy and stock farm. The animals look in excellent condition. Beef from cattle born and raised on the farm, and fed with sewage-grown products, bring the highest prices in the market, while the milk and butter find a ready sale.

For a long time the storm-water was the great bugbear of sewage-farms; but the problem has been solved at Croydon by keeping two large pastures, of twenty-five acres each, which are irrigated alternately in case of heavy rains, as so great a flow does not injure short grass.

The accompanying map shows the main points of interest in the Croydon farm. The description, kindly furnished by Dr. Carpenter, was prepared by him for a large party of

scientific men, who visited the farm at his request. The committee of management of the local board, consisting of Dr. Alfred Carpenter, chairman; Mr. J. S. Wright, Mr. Baldwin Latham, C. E., and Mr. Howard Martin, furnished their guests with a luncheon, of which the following is the bill of fare.

Bread and pastry, from wheat grown upon the farm; beef, from a young heifer which had been two years and a half upon the farm; veal, from a calf bred on the farm; vegetables, as salad, etc., grown on the farm; trout, *en Mayonnaise*, obtained from the river Wandle, into which the effluent water passes; confectionery, made with milk, cream, etc., also from the farm.

The party went away satisfied,—

"That a sewage-farm is not a swamp or marsh; that it does not injure the health of a neighborhood; that it does not damage residential property, except from the ideal point of view; that it turns poor land into land capable of producing luxuriant crops; that its produce is beneficial to cattle; that cattle fed upon sewage-produce are themselves healthy; that the food produced is fit for human consumption; that a large farm cannot be farmed successfully, except a large capital be invested in it; that the experience of sewage-irrigation on the same land for fifteen years will justify the capitalist in putting capital into sewage-agriculture, under favorable circumstances."

Dr. Carpenter showed that the death-rates had diminished in the vicinity of the farm (population 2,900). This fact showed, at least, that no influence unfavorable to health existed there.

DESCRIPTION OF THE MAP.

"A is the filter-house, on the site of the old filtering-tanks, which were immense nuisances to the neighborhood. The tanks have been filled up with town-refuse, and have been utilized as garden-plots for men in the employ of the local board. The workmen are allowed to take liquid sewage as they please. The crude sewage, as it comes from the town sewers, passes through one of Latham's Strainers. The extraneous matters which are removed (*i. e.*, lumps of

faeces, rags, paper, etc.) are mixed with dry straw and garden-refuse, collected from the dust-bins of the town. The compost is thus rendered comparatively inoffensive, and is partly used on the farm, and partly sold to market-gardeners in the neighborhood, at 2s. 6d. per yard. The machine is self-acting, the sewage itself being the moving power. About a yard and a half of manure is produced every day.

"Next is the open sewer, B. At this point the crude sewage passes on to the fields. The sewage is perfectly fresh, about three hours being occupied in its transit from the most distant part of the district to the filter-house. The quantity varies from three to eight or ten million gallons; the first quantity being the dry-weather supply, and the excess being due to the admission of a portion of the rainfall.

"The farm is given in outline on the plan; it consists of about 500 acres. That part which can be irrigated is bounded by a broken black line. There are generally 150 to 200 acres under rye-grass cultivation; 50 acres are meadow, and are mainly used for the purpose of cleansing storm-waters; 82 are under cultivation for market-garden purposes; the remainder has mangolds, or other roots or cereals.

"Field C, now under sewage, which is applied to alternate plots for twelve hours at a time, more or less, had wheat last year, and produced six quarters six bushels to the acre, and, with the straw, gave a return of £22 3s. 9d. per acre. The land has had no other manure than sewage for fifteen years. It was laid down with rye-grass in the autumn, and was cut for the first time May 14. The sum received for the cutting was £7 per acre. The second crop is now growing. The plot next to the wheat was occupied last year with potatoes, and produced £19 per acre. The rye-grass was sown too late, and had to be resown this spring. The first cutting realized £4 2s. per acre.

"One plot was sown with rye-grass in September last; the first cutting, April 24, produced £7 15s. per acre; the second, now cutting, realizes about £12 per acre. It is sold at from 4d. to 1s. 6d. per rod to cowkeepers and others, who send for it, and pay for it as they take it away.

"The plot E was market-gardened last year, and is now

growing oats (twenty-seven acres). When the oats are taken off, the land will be laid down with rye-grass.

"F* is the strainer for the sewage which comes from Norwood. It is similar in action to that at the filter-works. A portion of the farm near to this filter-house cannot be irrigated. The field is now market-gardened.

"F is laid down with rhubarb; it occupies 2 acres 2 roods, and this year has produced £66 6s. 9d., or £26 10s. 8d. per acre, and will be better next year. The irregular plot numbered 3 on plan has been an uncultivated shaw. It has been grubbed up at an expense of about £14 per acre, and is for the first time planted with potatoes. It has been a dead weight to the farm for years, producing abundance of weeds.

"G: rye-grass for four years was broken up last autumn, and has now a crop of cabbages, with some seed-beds for planting out, upon it.

"H and I are under rye-grass; the first portion sown last September; first cutting April 20; second cutting June 3. A portion weighed from this field, in the presence and for the information of several agriculturists, during the recent show, gave a produce of $15\frac{1}{2}$ tons per acre. This plot consists of — acres, and has realized this spring £111 13s. 6d. Another portion was resown this spring, was cut April 30, and a second crop is now growing. A portion has been fed off by sheep.

"The hay from rye-grass, when made before the pollen drops from the flowers, is much enjoyed by cattle.

"The outfall will be found at Z. An analysis of the effluent was recently published by the Rural Sanitary Authority, which was made by Dr. Hassall, and which gives the following as the result in 100,000 parts:—

Total hardness, ...	23.8
Temporary hardness, ...	15.1
Permanent hardness, ...	8.7
Total solids, ...	44.
Nitric acid, ...	2.15
Free ammonia, ...	0.0082
Albuminoid ammonia, ...	0.0297
Chlorine, ...	3.0442

"The nitric acid may be in the water as harmless nitrates, a large quantity being known to be present in superficial chalk waters. Having to go to the second figure in decimals for the ammonia, appears to be most satisfactory. At the same time, it is not suggested that the effluent water should be ever used for drinking purposes. Analysis made by Dr. Frankland, and taken from the effluent stream without notice, has given a much more favorable result than is given by Dr. Hassall. Near to the outfall is the water-cress bed, and a much larger plot at the south-west corner of the farm. The chairman of the committee on management was not on the board when this larger bed was laid out and let to the grower.

"X is a meadow used principally for storm-water.

"W.—Keeper's gate. Rye-grass, sown in the autumn of 1873, was cut seven times last year, including one cutting which extended into January of this year. It was cut on March 25 of this year, again about May 10, and is now a third time in process of cutting.

"S is now in the hands of the market-garden manager; but Mr. Horsely, the farm-manager, will take possession in the autumn, and lay it down again in rye-grass. It has been cultivated for market-garden crops without other manure than sewage for three years.

"T is a meadow. In it will be found most of the stock belonging to the local board, including calves, yearlings and heifers. All the younger stock has been produced on the farm, and fed entirely on sewage-produce. Other fields, right and left of the road, will be observed under rye-grass or other kinds of cultivation.

"O.—The rye-grass was resown this spring, and the second cutting is now growing.

"P has been broken up this spring, and is preparing for autumn cabbages.

"It is intended to make hay from the second cut upon Q and R.

"I and L are mangolds. A portion of these plots were mangolds last year. About 700 tons were raised on the farm; one-half were consumed by stock on the farm; 350 sold by auction in the spring, and realized 25s. and 26s. per ton.

"K was also mangolds; it is now planted with cabbages, and

when they come off, will be laid down in wheat on a portion of this field. Forty-four tons of long, red mangolds were grown to the acre on portions of this plot."

Bedford.

The accompanying map is illustrative of an admirably-managed farm.* The town has 18,000 inhabitants, the dry-weather flow of sewage is 700,000 gallons a day, and the average annual rainfall is only 21 inches.† The main sewer is about a mile and a half long, and is large enough to serve as a reservoir during the night, and with a storm-overflow into the river, to be used in case of prolonged rain. The flap is self-acting, so that an excessive rainfall during the night will pass off without trouble.

The sewage passes through a simple grating to screen out rags, paper, etc., and is then raised by pumping into a cast-iron tower, twelve feet high and seven feet in diameter, whence it is distributed to the various parts of the farm by gravitation; the three different plots (see map) being of different heights and requiring different degrees of elevation of the sewage.

The sewage is distributed by the pipe-system;‡ there is, therefore, absolutely no odor, and an advantage is thought to be gained in preventing the volatilization of the ammonia.

Onions, carrots, turnips and other vegetables are raised, and the crops look promising. The effluent is clear, and has no disagreeable taste. The river Ouse, into which it runs, is bright and sparkling. In winter the effluent does not attain the same degree of purity as in summer; but still it does not putrefy nor foul the river, and it satisfies, even then, the standard of the Rivers Pollution Commission.

The town owns 27 acres of the land, and leases the re-

* It will be seen that the farm is really divided into three plots. The sewage is delivered by the main conduit to the pump, whence it is raised to a sufficient height in the stand-pipe to allow of its being distributed over the farm by gravitation. The positions of the main carriers, covered by an embankment of earth are given, with their sizes. The lateral sewage-carriers are simply trenches in the earth. The positions of the cart-roads are also given.

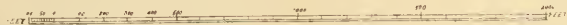
† About one-half as great as in most parts of Massachusetts.

‡ See Fig. II., page 340.

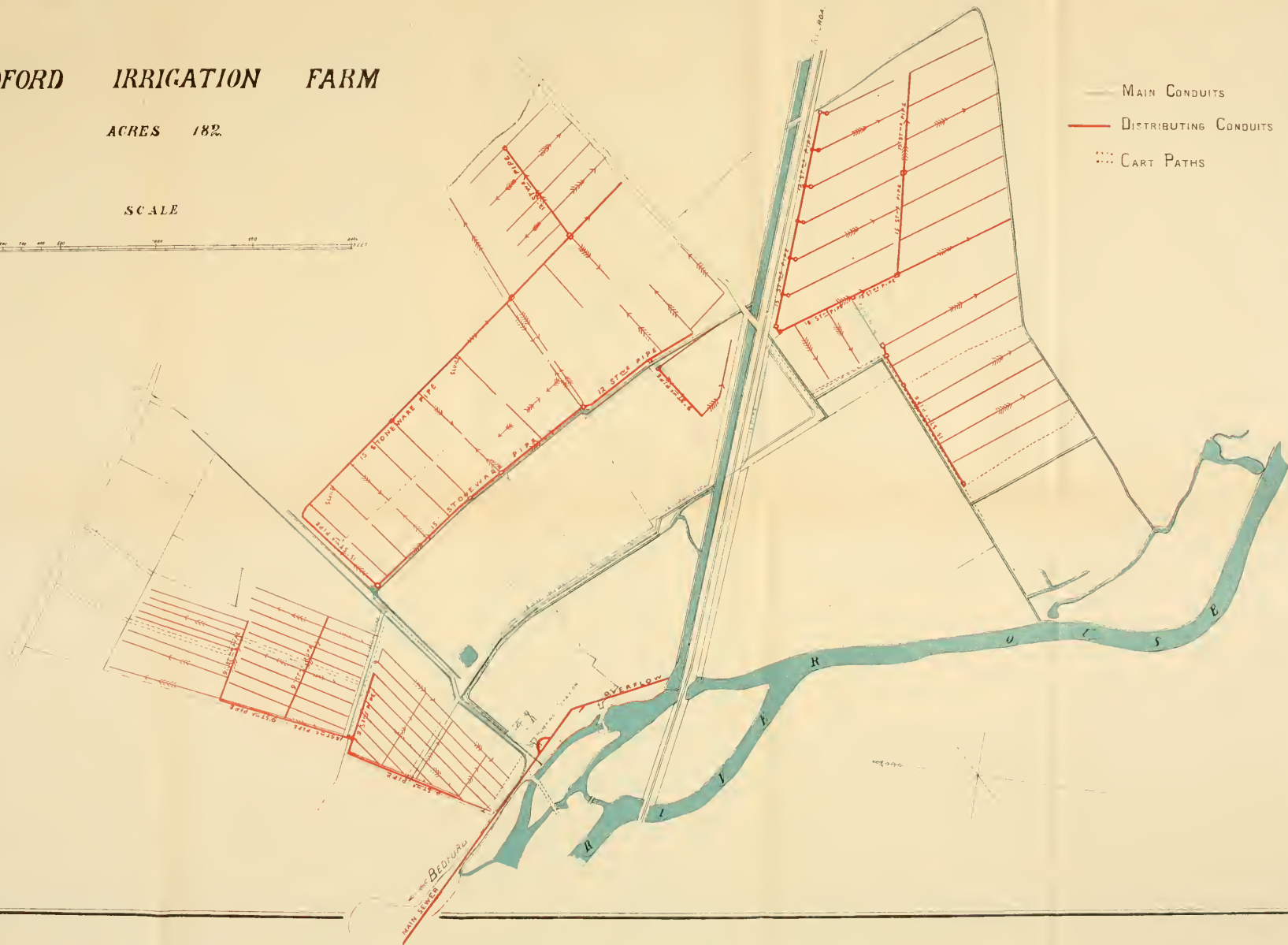
BEDFORD IRRIGATION FARM

ACRES 182.

SCALE



- MAIN CONDUITS
- DISTRIBUTING CONDUITS
- ... CART PATHS



mainder, 155 acres. There has been no extravagant expenditure, and the receipts, since operations began, August 18, 1868, show only a very slight loss. From August 18, 1868, to December 31, 1871, there was a deficit of £1,106 7s., which was to have been expected in the beginning. In the year 1874 there was a profit of £180 15s. 4d.

The following accounts, for which, with the map, I am indebted to Mr. John Lund, borough surveyor, will be found of interest:—

BEDFORD LOCAL BOARD.

Statement showing Total Expenditure in respect of Sewerage, Water, Embankment, and Irrigation-Works, up to 31st December, 1871, from August 18, 1868.

SEWERAGE-WORKS.

L. B. Moore, Contract No. 1, ...	£17,083	15s.	7d.
“ “ loss caused by floods, ...	200	0	0
“ “ extra work, ...	18	10	0
Ventilating grates, man-hole covers, lamp-hole covers and castings, ...	786	4	10
Compensation for injury by works, ...	356	13	4
Extension of main to Britannia road and Muswell road, ...	185	5	1
Miscellaneous expenses, ...	106	9	1
	£18,736	17s.	11d.

WATER-WORKS.

Contract A, steam-engines, ...	£1,950	6s.	0d.
“ B, cast-iron pipes, ...	5,091	3	2
“ C, sluice-valves and hydrants, ...	755	3	9
“ D, laying mains, ...	2,510	11	6
“ E, Reservoir, ...	1,710	19	11
“ F, engine-house, ...	2,792	5	10
Purchase of land, ...	1,230	0	0
Compensation for injury by works, ...	142	0	0
Sinking wells, ...	440	3	6
Extra engine, boiler and pumps, ...	221	9	3
Hire of steam-pumping-engine, ...	248	7	5
Pipes, ...	210	17	7
Coal, ...	84	18	3
Labor, ...	77	6	7
Miscellaneous expenses, ...	183	17	5
	£17,649	10s.	2d.

IRRIGATION-WORKS.

Contract A, steam-engines, ...	£890	18s.	8d.
“ No. 2, iron pipes and cylinders, ...	748	4	4
“ No. 3, wall, ...	136	2	6
“ No. 4, engine-house, ...	442	15	2
Purchase of land, ...	250	0	0
Compensation for injury by works, ...	53	1	0
Labor, ...	1,213	9	1
Pipes, ...	1,590	9	7
Farm-buildings, ...	451	11	8
Horse-hire and carting, ...	331	3	9
Horses, carts and implements, ...	252	0	9
Coal-shed, ...	147	16	6
Fixing boiler, ...	78	18	7
Contract for wells, ...	57	10	0
Miscellaneous expenses, ...	352	18	10
	£6,997	0d.	5d.

EMBANKMENT-WORKS.

Total cost, ...	£2,703	15s.	8d.
Compensation for injury by works, ...	1,785	0	0
	£4,488	15s.	8d.

GENERAL.

Superintendence of works, ...	£1,091	15s.	4d.
Lawson, Commission, ...	2,200	0	0
Lithographing specifications, stationery, and advertisements, ...	138	5	6
Law charges, including costs of solicitors of Provident and Economic Life Offices, ...	444	17	8
Miscellaneous charges, ...	1,276	8	0
	£5,151	6	6

SUMMARY.

Sewerage-works, ...	£18,736	17s.	11d.
Water-works, ...	17,649	10	2
Irrigation-works, ...	6,997	0	5
Embankment-works, ...	4,488	15	8
General, ...	5,151	6	6
	£53,023	10	8

BEDFORD IRRIGATION-FARM.

Statement of Cost of Pumping the Sewage on the Land, Farming Expenses and Receipts up to 31st December, 1871, from August 18, 1868.

Labor, ...	£668	4s.	3d.
Salary of manager, ...	247	16	0
“ of engine-driver, ...	190	19	4
Ploughing and threshing, ...	22	5	0
Rent, rates, and taxes, ...	2,029	10	3
General outlay:—			
Coals, ...	£466	18s.	1d.
Tradesmen's bills, ...	69	10	7
Horse-keep, ...	286	7	1
Seeds, ...	197	5	6
Insurance, ...	0	6	0
	1,020	7	3
	£4,179	2s.	1d.

RECEIPTS.

Total sales of crops by auctioneer, less commission, ...	£3,144	17s.	0d.*
Deduct amount due from Mr. L. J. Ibbs, ...	248	11	0
	£2,896	6s.	0d.
Miscellaneous receipts, ...	176	9	1
	£3,072	15s.	1d.

IRRIGATION-FARM, BEDFORD.

General Account and Balance Sheet at Stock-taking, Dec. 31, 1874.

DR.

Stock, December, 1873, ...	£431	0s.	0d.
Working-plant, Dec., 1873, ...	222	4	0
Labor, ...	£492	9s.	7d.
Manager, ...	112	11	1
Engineer, ...	62	16	6
	667	17	2
Tradesmen's bills paid, ...	£79	11s.	7d.
Tradesmen's bills owing, ...	30	10	2
Coals, ...	260	2	7
Coals owing, ...	32	8	0
Horse-corn, etc., ...	40	8	9
Manure purchased, ...	10	0	0
Horse and bullocks purchased, ...	133	10	0
Seeds, ...	102	8	4
Amounts carried forward, ...	£688	19s.	5d.
	£1,321	1s.	2d.

* The first sale of crops took place on the 2d of September, 1868.

<i>Amounts brought forward,</i>	£688	19s.	5d.	£1,321	1d.	2s.
Hire of horses for ploughing, ...	30	3	0			
Mr. Stafford's commission and expenses, ...	114	12	6			
	£833	14s.	11d.			
Deduct bills owing, 1873, ...	53	4	2			
				780	10	9
Rents,—						
The Rev. Champion, ...	£126	14s.	11d.			
Captain Polhill-Turner, ...	421	11	3			
Duke of Bedford, ...	244	8	2			
Corporation of Bedford, ...	123	9	8			
L. & N. W. Railway,—sewer under railway, ...	1	0	0			
				917	4	0
Poor-rates, ...	£92	0s.	6d.			
Income-tax, ...	18	3	2			
Land-tax, ...	3	1	2			
Insurance, ...	0	10	0			
				113	14	7
Permanent works, ...				24	2	8
Oats, ...				16	5	0
Hay, ...	£48	2s.	6d.			
Beans, ...	59	10	0			
				107	12	6
Balance for 1874, ...				180	15	4
				£3,461	6s.	0d.

CR.

Sale of crops, ... £2,515 13s. 10d.

Stock in hand and purchased, 1874,—

30 tons of hay, £5, ...	£150	0s.	0d.			
26 loads of beans, 28s., ...	38	8	0			
2 acres of mangolds, £20, ...	40	0	0			
6 tons of potatoes, £4, ...	24	0	0			
16 acres of growing wheat, 50s., ...	40	0	0			
Bean, barley, and oat straw, ...	15	0	0			
Rye-grass hay, ...	10	0	0			
Pickling-cabbages, ...	12	0	0			
Carrots, ...	25	0	0			
12½ qrs. oats, 26s. per qr., ...	16	5	0			
6 acres of growing cabbage, £5, ...	30	0	0			
9½ acres of growing rye-grass, 50s., ...	23	15	0			
8 bullocks, £15, ...	120	0	0			
				544	8	0

Working-plant and live and dead stock,—

4 horses, ...	£175	0s.	0d.			
3 carts, £8, ...	24	0	0			
1 horse-roll, ...	7	10	0			
1 double plough, ...	3	0	0			
1 single plough, ...	1	10	0			
1 horse-hoe, ...	4	0	0			
1 scuffler, ...	4	0	0			
2 sets of harrows, ...	2	0	0			
1 pulper, ...	2	10	0			
1 chaff-cutter, ...	4	0	0			
1 bean-mill, ...	2	10	0			
6 wheelbarrows, ...	1	4	0			
4 sets of harness, ...	6	0	0			
1 cultivator, ...	2	15	0			
2 cow-cribs, ...	3	0	0			
Office furniture, ...	2	10	0			
Coals in stock, ...	24	0	0			
				£269	9s.	0d.
Sewage-works, ...				24	2	8
Hay, ...	£48	2s.	6d.			
Beans, ...	59	10	0			
				107	12	6
				£3,461	6s.	0d.

J. E. CUTCLIFFE,
W. ROFF,
HARRY THODY,
THOMAS HALL BARKHAM,
JAS. THOS. HOBSON,
Farming Committee.

The health of the people has not suffered from having a sewage-farm a mile and a half distant from the town. The corrected mortality, as given by Dr. Prior, medical officer of health, is: Number of deaths, 1870, 348; 1871, 329; 1872, 326. Death-rate per 1,000 for the three years, 20.189.

Tunbridge Wells.

There are two irrigation-farms for disposing of the sewage of the 25,000 inhabitants of this town, as sufficient land could not be got in one place.

The northern farm, of 120 acres, is two miles and a half from the town. The land is quite hilly, and the sewage is conveyed in one case from one plot to another by an inverted

siphon. The distribution is performed by gravitation, and the carriers are ingeniously arranged so as to wind round the slopes and irrigate all parts in succession. The soil is tough and firm, and required underdraining. The sewage from the main conduit is collected in two large tanks for precipitating the bulk of the solid matters. This sludge, when removed, is the source of offensive odors which can be noticed at a considerable distance. When visited last year, there was pretty generally over the farm a slightly disagreeable odor arising from the carriers. It was found that they had not been thoroughly cleaned during the hurry of harvesting the crops.

Two useful acts may be learned here: 1st. That sewage-irrigation may be applied to uneven surfaces without undergoing the enormous expense of levelling the land. 2d. That sewage-farms require constant care to keep them from becoming nuisances.

The southern farm of 150 acres, three miles from the town, is an actual garden, covered with luxuriant crops,—grass, turnips, beets, carrots, hops, etc. Some of the roots were of extraordinary size. The fine herds of cattle feed on nothing but what is grown on the farm with sewage-irrigation, and they drink the effluent water. The soil is light, and has required underdraining in only a few spots. The land is hilly, and the sewage is distributed over it in open brick carriers by gravitation; no pumping is needed.

About a mile from the farm, tanks have been constructed for precipitating the solid parts of the sewage (chiefly sand), with the double hope of getting some revenue from its sale, and of keeping the carriers free from obstruction by deposits. The process does not serve either purpose. The farmers at first bought the mud at two shillings a ton; now they give sixpence a ton, when they are not busy, and have plenty of time to cart it. The tanks are a few rods from the road, and out of sight from it. Still, the complaints of bad odors, on the part of the many strangers who often pass, were so frequent, that now the sludge is stirred up every morning, and forced down the conduits to the farm with the liquid parts.

At the time of a visit last year, there was absolutely no unpleasant odor in any part of the farm. The conduits, how-

ever, if not running full, are the source of nuisance, unless they be frequently cleaned. This is done with stiff brushes.

In 1874, there was a clear profit of £40, after deducting all expenses, from the sale of the crops. In 1875, there was a deficit, owing to the frequent and heavy rains during the year. The farmer in charge, an educated agriculturist, complains that, under the necessity of keeping the streams pure, he must irrigate even when he knows it is doing harm to his crops. He thinks that the process is still in its infancy, that many improvements are to be made, and that sewage-farms will eventually become very profitable.

Leamington.

In 1870, the authorities of this town, having proved the precipitating processes to be costly and expensive failures,* gave up their tanks, and, in conjunction with the towns of Killington and Milverton, made a contract to deliver their sewage for thirty years upon Heathcote Farm, belonging to the Earl of Warwick.

The land is a rich loam, with a gravelly subsoil; it has been prepared for irrigation at a cost of £10 an acre, including levelling, subsoil-drains, carriers, etc. A million gallons a day, the sewage of 24,000 people, are pumped through a main conduit two miles and a quarter long to an elevation of 132 feet, the highest point on the farm,† whence it is conducted through earthenware pipes to the various parts of the farm, to be distributed by trenches dug in the earth. There are, in different parts of the farm, eight "hydrants" or wells, which are simply circular reservoirs, four feet wide, into which the sewage passes to be distributed in any required direction by means of four effluent main carriers, any one of which may be opened or closed at will.

Four men are kept steadily employed in attending to the details of the irrigation, turning sewage off and on, keeping trenches clear, etc., etc.

* After having expended £5,000 in litigation, the local board received an injunction from the Court of Chancery to cease putting either their sewage or the effluent from it into the rivers Avon and Leam.

† There is a reservoir capable of holding the supply of forty-eight hours; but it is to be used only in case of necessity, as the sewage is thought to lose materially in value by standing long enough for putrefaction to begin.

The surface-water, the great bugbear in sewage-irrigation, is diverted by storm-overflows into the River Leam.

The land is usually saturated with sewage before planting. Roots are irrigated for a few hours every eight days, and care is always taken, with all crops, not to let the sewage come in contact with the leaves. Eight crops of rye-grass (cut when about two feet high, and not ripe) are raised each year, and fed green to the stock. Mangolds (eight inches in diameter, and producing 82 tons to the acre), turnips (obtained fresh almost continuously through the season), luxuriant crops of wheat, hay, peas, beans, carrots, parsnips, cabbages, celery, rhubarb and strawberries, are raised here by sewage-irrigation, and reach the market earlier than those from other farms.

To sight and taste, the effluent seemed as good as the purest spring-water.

A herd of forty cattle is kept on the products of the farm, and they drink the effluent water mingled with that of a small brook. Even their pasture is irrigated. The beef, milk and butter find a ready sale, and command the highest market prices.

The result of four years' experience has shown that the land has increased very much in productiveness. There has been a large annual outlay for stock, etc., the benefit of which is just beginning to be felt. For the year 1875, in spite of a wet season, the income will, without much doubt, cover all expenses, including rent of land, interest on capital, etc., although the Earl of Warwick pays £450 a year for the sewage, delivered on the farm. This success is due to the excellent management of Mr. Tough, the earl's manager, as well as is the fact that not a single complaint has ever been made of any offence.

The rate-payers expended, in 1874, £1,046 to deliver the sewage at the farm. In return for this they received £450 from the Earl of Warwick, leaving £596 as the cost to them for the year. The cost of pumping, including fuel, is over £600 a year. Therefore, if the sewage were delivered by gravitation, without pumping, there would be quite a fair profit on the whole operation.

The accompanying map, for which I am indebted to Mr.

HEATHCOTE FARM.

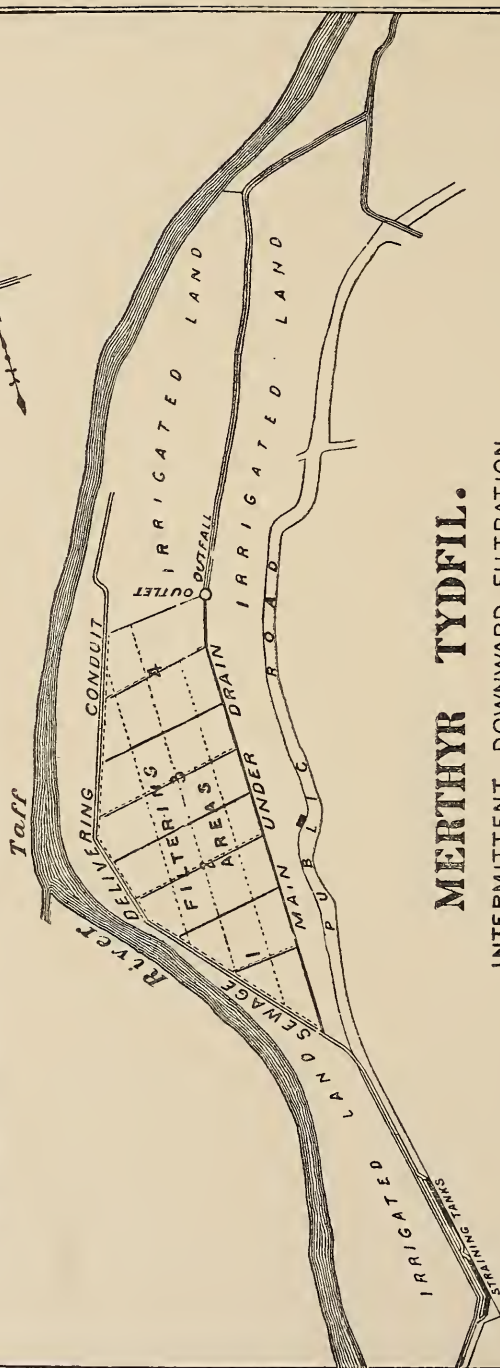
Area 400 acres.

Scale of Chains
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Main Sewer ———
Deep drains ———
Wells for inspecting small drains *
Boundary of Farm ———



NOTE. THE DOTTED LINES SHOWN ON THE FILTERING AREAS
ARE DIVISIONAL PATHWAYS.



MERTHYR TYDFIL.

INTERMITTENT DOWNWARD FILTRATION.

Scale 12 Chains to One Inch.

Tough, shows the important facts with regard to the farm. The sewage-carriers are under ground, follow the boundaries of the various fields, and are not indicated on the map. The subsoil-drains, as shown, discharge into the brook. The limit of the irrigated area is marked by a heavy black line.

Merthyr Tydfil, Wales.

In the early part of 1870, application was made to parliament for power to take land for irrigation, and an Act was passed some months later giving the town power to take a lot of 393 acres. Those persons who had obtained the injunction forbidding the town to pollute the river Taff, which had led to the application to parliament, were not satisfied that the nuisance would be removed speedily enough. They therefore applied for a second injunction, when the matter was placed by the court in the hands of Mr. J. Bailey Denton, who determined to carry out the system of intermittent downward filtration suggested by Frankland.*

The sewage of 40,000 people passes from the town, three miles distant, by the action of gravitation. On the way to the farm it flows through a straining-tank, filled with refuse slag from the iron-works, by which the coarser parts are intercepted.† It is finally distributed, through covered earthenware pipes, upon a field of twenty acres, divided into four plots of equal size, each of which is used six hours at a time, with eighteen hours of rest for aeration. The four plots are marked 1, 2, 3, 4, on the map.‡ The sewage flows uniformly

* This method has been in use for two seasons at Kendal, where 400,000 gallons, the sewage of 13,500 people, are filtered on five and a half acres of land. The effluent is a colorless and fair potable water. In ordinary weather, when the river is at its medium level, the outflow from the under-drains averages one-third of the quantity of sewage delivered on the land, the remaining two-thirds being lost in the gravel. When the river is low, the whole sewage disappears in the gravel subsoil. Crops were sold, the first year, for. £150, or £80 less than the expenditure, making a tax on the rate-payers one-half as great as is required to carry on the Croydon farm.

A third town—Rotherham—has recently applied to Mr. Denton to introduce his system there.

† It was found that without this precaution the surface of the filtering-area became somewhat clogged.

‡ This map is copied from one given by Dr. T. J. Dyke, in a paper read at the annual meeting of the South Wales and Monmouthshire branch of the British Medical Association, in 1872.

over each plot, with a fall of one in one hundred and fifty from the conduit to the main underdrain, where it is arrested by an embankment. The main underdrain is six feet deep, and serves to carry off the effluent to the river. The lateral deep drains are of the same depth, and placed only twelve feet apart.

The soil is admirably adapted to this system, being a light loam, with a gravelly subsoil in some places sixty feet deep. The effluent is quite pure,* as is shown in the accompanying table, furnished by Dr. Dyke, and far above the standard demanded by the Rivers Pollution Commission. Their standard, indeed, is not yet enforced by law, is not attained by any of the precipitating processes, and is thought by many persons to be too high. The Thames Conservancy Board are somewhat more easily satisfied, but have been criticised adversely for that very reason.

* It should be said that it is mingled with quite a large subterranean stream, and is therefore much diluted before its final discharge into the water-courses.

Contrary to the expectation of the Rivers Pollution Commission, it was found that good crops could be raised on land which received such an enormous quantity of sewage. It was also feared that the soil would become clogged in the course of time. The experience of five years at Merthyr has shown that this is not a likely result, at least with a gravelly subsoil.

In 1872, fifty-five acres, and in 1875, one hundred and fifty acres were added to the farm for ordinary irrigation; not because intermittent downward filtration was inadequate to purifying the sewage, but because the local board desired to have the benefit of the additional land for raising crops to repay their annual outlay. The filtering-area is now used half the time. Large crops are raised in both fields.

The summer is shorter in Wales than in England. The first crop of rye-grass is cut in April, the last in November; there are four in all.* The ground freezes to a depth of two feet; but, as the sewage is warm, this does not interfere seriously with irrigation.

The cost of carrying on the farm is about £1,050 a year, against £1,000 received from sale of crops. Here, as elsewhere, the testimony is freely given, that under private management the farm would undoubtedly be profitable. Corporations do not make good farmers.

In Dr. Dyke's report for 1874, he has given interesting testimony as to the milk of cows fed on sewage-grown grass. The district is occupied largely by miners who have large families. Dr. Dyke testifies to the good health of the children, as follows: "There are many hundreds of children brought up on this milk of cows largely fed on sewage-grass, and the death-rate from diarrhœal diseases is very low."

Gennevilliers, France.

Two hundred wagons are employed in Paris in emptying the cesspools, and the cost is 1,600,000 francs a year. As the scavengers are obliged to enter narrow courts, and even cellars, in their work, the stench, in spite of disinfectants, is often intolerable. Seven hundred and fifty thousand cubic

* At Croydon, eight crops are cut; the first in January, the last in December.

meters of the cesspool-matter is piled up at Bondy, just outside the city, and the authorities do not know what to do with it. In the meantime, the Seine has become so seriously polluted with the sewage of the city, as to give occasion to frequent and loud complaints, while 200,000 francs a year are expended in removing from it sewage-deposits.

Under such circumstances, the use of the water-closet is becoming more and more general, and the opinion is pretty well established that the filth of the city sewers must be purified by irrigation.

In England, a great obstacle to successful irrigation has been the fact that the land is held by wealthy land-owners, who demand exorbitant prices for it. As great a difficulty is encountered near Paris, from the land being parcelled out in small lots, owned by an ignorant peasantry who are very capricious, sometimes wanting the sewage and sometimes not.

Experiments begun in 1867 on a small farm of twelve acres, carried on by the sewer department, showed very favorable results, and farmers applied to have the sewage applied to their land. The place selected was a peninsula of four thousand acres formed by a bend of the Seine, quite flat, lying six or seven meters above the bed of the river, and having a poor, alluvial soil, largely sand and gravel. It is, of course, admirably suited to the purpose.

Up to 1874 the area irrigated was considerably extended each year, at the request of the farmers holding the land. During 1875, scarcely any additions were made, although the city is glad to deliver the sewage free of charge upon any lots in the vicinity. The land is so near the city (a mile and a half beyond the walls), that the owners are beginning to think that its use in this way will prevent their getting larger profits from its sale for building purposes, docks, etc.

The main sewers of Paris have two outlets. At Clichy, 260,000 cubic meters of sewage are discharged daily, of which 40,000 are forced by pumps across the river through iron conduits passing along the framework under the bridge. At St. Denis, 50,000 cubic meters are discharged each day; this can be distributed by gravitation. The main carriers are of brick; the laterals are simply small trenches in the earth. For summer-irrigation, beds are made a single meter in width, over

which the sewage does not flow, but through which it must sink from the trenches, finally reaching the roots. Winter-irrigation consists in flooding the land several inches deep. The level of the ground-water is from four to six meters below the surface, and the land is very porous, covered with a layer of fine sand, so that a single acre is sufficient to purify the sewage of seven hundred persons.* The farmers use the sewage, or let it run into the Seine, as they feel inclined.

The crops raised are almost exclusively vegetables for the Paris market. They are bought readily; the Grand Hotel is supplied with them. In fact, the products of the sewage-gardens, being large and fine looking, command the highest prices, a single acre often yielding a return of fifteen hundred or two thousand francs a year.

When the farm was visited, there was what is called in England a stink over the whole place, which was attributed to three causes: 1. The sewers of Paris not being self-cleansing, the sewage has advanced somewhat in putrefaction before reaching the fields. 2. The trenches for distributing the sewage were foul, as the liquids stand in them for so long a time. 3. The heat is more intense in France than in England.

No ill effect, however, has been noticed on the health of those residing near, though a village has sprung up in the very midst of the sewage-plots.

The city has expended several hundred thousand francs in pumps, etc., to carry out this enterprise, for which they have no return. The authorities are now carrying out a project which will make them independent of the petty land proprietors. This consists in carrying the sewage still farther down the river, and using it on some land belonging to the State.

It has been proposed to carry an intercepting sewer down nearly to tide-water, and to utilize the sewage on all proper places on the way, so that the farmers can use it when they consider it for their profit to do so, and at other times let it go. The land-owners at Gennevilliers have found out what has been learned over and over again in England, that, if they purify all the sewage by irrigation before letting it run into the rivers, they cannot expect the profits to be large.

* Seven hundred and fifty acres have been thought by the Berlin Commission sufficient to purify the sewage of that city; or one acre for about a thousand persons.

The only experiment at Paris which is satisfactory from a sanitary point of view, as affording a solution of the question of purifying the river, is that of Mr. Hope; but he has found it impossible to get over 108 acres of land. His farm is managed precisely like his other, so well known, at Romford.

Dantzic, Germany.

When the English contractors Aird undertook to build the system of sewers so scientifically planned by Wiebe for this city of 80,000 inhabitants, they agreed to keep them in order and to purify the sewage by irrigation for thirty years, at an annual expense to themselves of about \$6,000 or \$7,000 for keeping the pumps and conduits in order alone. They were to have the rent of 1,000 acres free, and all the income from the crops accrues to them. The sewage is carried nearly three miles, and is at present applied to 250 acres of what was at the beginning of the experiment an almost barren sand-beach close to the edge of the Baltic Sea.

During the first year, so much time and expense were laid out in levelling the sand-hills, and the sand itself blew about so much, that the results were not very encouraging. The preparation for the sewage of a single acre often cost sixty dollars.

In 1872, however, the second year of the experiment, fifteen acres were got under cultivation; and now 250 acres are covered with luxuriant crops, while some of the land has become very fertile.

On the 1st of January, 1875, according to the report of Mayor v. Winter, there were cultivated as follows:—

Rye-grass, ...	82 acres.
Turnips, ...	45 "
Rape, ...	17 "
Beet-root (the previous year with oats), ...	30 "
Buckwheat, ...	25 "
Barley, ...	6 "
Tobacco and maize, ...	6 "
Swedes (the year previous with beet-root and flax), ...	7½ "
Caraway seeds, ...	¾ "
Aromatic herbs (such as thyme, lavender, etc.), ...	25 "
Vegetables, ...	5 "
Flower-beds and strawberries, ...	¾ "

The sewage is conveyed to the farm by pumping it through a sewer four miles long, to a reservoir, whence it is carried by a single large conduit, passing through the farm, to the sea. This is made of wood, a poor conductor of heat, to protect the sewage as much as possible in winter. The distributing carriers are simple trenches, at a considerably lower level, so that the sewage may run freely during cold weather.

The trial at Dantzic is of especial interest to us, inasmuch as it was undertaken for economical reasons, to save the sewage and to reclaim some almost worthless land. Moreover, the climate is quite like that of Massachusetts, with the same intense heat in the summer and almost as great severity of cold in winter.* The ground is usually frozen to a depth of three or four feet, for about three months; the snow is often several feet deep.

The sewage in the main conduit is kept at a depth of a foot and a half, and is constantly flowing. It maintains a temperature, in winter, of 50° to 60° Fahr.: much higher than the summer temperature, on account of the free use of hot water at that time in the city. It flows out under the snow, through the many furrows prepared for it, leaving a thick crust to be ploughed into the land in the spring. About thirty feet from the conduits the sewage often freezes; and during the months of extreme cold, though the sand is so porous that the sewage sinks into it readily at all times,† filtration alone can be depended upon. Nevertheless, if the plots of land are large and frequently changed, the purification of the sewage is, even in winter, more complete than can be accomplished by any of the precipitating processes.‡

From a sanitary point of view, sewage-irrigation has proved a marked success in Dantzic. A map, showing the general plan of the city and of the farm, is here given.

* In the winter of 1874-75, the mercury stood at -17° Fahr. It reaches -6° or -8° every winter.

† Three times only, in January and February, 1875, and then for only a few days at a time, has irrigation at Dantzic been stopped by the cold. Roots of grass are destroyed by ordinary winter-irrigation. If, however, they are kept constantly covered with sewage, no harm is done.

‡ That there would be danger in using water from wells near by, is evident. Such water cannot be safely drunk at any time.

**MAP OF
DANTZIC**
showing the
Area Irrigated by
Sewage.





Durham County Insane Asylum, England.

In the accompanying sketch, taken from one of the reports of the Rivers Pollution Commission, the irrigated land, thirty-one acres and a half, is shaded, the vegetable-garden being quite close to the walls of the asylum. The main carriers for the sewage are represented by dotted lines. The asylum, with five hundred occupants, is represented by the figure 1; 2 is a workshop; 3, 4, 6, 7, 8 and 9 are farm-houses, porter's and gardener's houses, and cottages.

This method of disposing of the sewage of public institutions is quite common in England. It has been very successful, both from a sanitary and an economical point of view. In some asylums, all the vegetables used during the year are raised by sewage-irrigation. In such places, the labor costs almost nothing; and every additional interest or occupation benefits the patients in a degree which it would be difficult to measure in dollars and cents.

Dr. Boyd, medical superintendent, and Mr. Whitehead, C. E., testified that sewage-irrigation had been in use at the Somerset County Asylum for nineteen years; that the land had very much improved in value; that the sewage was completely deodorized soon after its application to the land; that there were no bad smells even in warm weather, and that no sickness or unpleasant results had been in any way due to irrigation with the sewage.

Augusta, Maine.

The sewage of the State Insane Asylum, in this city, became so offensive, that Mr. C. B. Lakin, the treasurer, carried out a system of irrigation which has been very efficient, and which is almost the only one which has stood the test of experience in this country.

The sewage passes by gravitation into large tanks, where it is mixed with a large amount of absorbents (straw, leaves, muck, etc.). The solid parts are from time to time carted on to the land, and the liquid passes off, often quite clear and sparkling, to be used on the land in irrigation. A portion flows over a few acres, from which three crops of fine hay were cut last summer. Another portion is used in hose-

irrigation of the vegetable-garden, care being taken not to sprinkle the leaves. A third part is carried to different parts of the farm and distributed from a cart, which is made to discharge the sewage upon the land by the removal of several plugs. It is filled from the top, and acts on precisely the same principle as an ordinary street-watering cart, although different in construction. Even if clear, transparent, and odorless, this fluid soon becomes turbid, foul-smelling, and finally almost black.

Seven thousand gallons of sewage are disposed of in this way each day. The results obtained have been as follows:—

1. What was formerly a nuisance has become inoffensive.
2. The hay-crop on the land irrigated by gravitation has increased sixfold. The other crops have increased somewhat.
3. The expense is fully met by the greater value of the crops raised. It should be said, however, that much of the labor is performed by patients, and costs nothing.
4. Most important of all, the fact is established that sewage, at least on a small scale, can be purified by the soil, in our climate, even in the winter. When the mercury stood at nearly 0° Fahr., and the ground was frozen hard, the sewage was found to disappear very soon after it was put upon the land. In the spring, the early rains wash any refuse that there may happen to be deep into the soil, and no offensive odors are noticed. The surface of the ground is then sometimes found covered with a brownish scum.

The "Waste of Sewage."

Captain Vetch, R. E., estimates the value of the *excreta* of one individual to be \$1.25 a year. Dr. Thudicum places the average for all ages at \$2.12; and some of the German observers consider it worth \$2.60. Upon these and other estimates, Liebig, Lawes, Gilbert, Hoffman and Way, and others, give to the ordinary sewage of English cities a value variously estimated at from one cent to four cents a ton. Considering the large amount of water used in this country, and our greater rainfall, it is probably fair to place the theoretical value of the sewage of our cities not higher than one cent a ton. It cannot be said to have any commercial value,

as the cost of utilizing it must exceed any return that could be obtained under most circumstances. In regard to public institutions, jails, etc., where labor could be got at small cost, and where it is a decided advantage to be able to give the inmates any employment, the experience of the asylum at Augusta warrants us in saying that sewage can be utilized, even in our climate, without loss.

From a large number of analyses published in the fourth report of the State Board of Health of Massachusetts, the late Secretary of the Board and Prof. Nichols estimate the sewage of Boston to possess one-half the fertilizing properties of the average sewage of English cities and towns, and to be worth about one cent a ton. This estimate was based chiefly upon the proportion of ammonia present. If we use the "total solid matter in solution" as a basis for our comparison, Boston sewage will be seen to have a somewhat higher comparative value, even after making due allowance for a large excess of salt in it. In a word, our sewage is more dilute, as we use water very freely for all purposes.

Considering the very dry character of the soil near Worcester, and the parching heat of our summers, however, this dilution may prove a benefit, rather than an evil, at least for that locality. Arrangements can easily be made to exclude the greater part of any excessive rainfall* from the irrigated fields.

The comparative values of our sewage and that of other places, may be approximately estimated from the following table:—

* Our water-supply and our rainfall are both about twice as great as in the majority of the English and German cities and towns, which have adopted sewage-irrigation. They are about the same as in West Derby.

Table showing the Composition of Sewage.

[Parts per 100,000.]

COMPOSITION.	Boston.*	Worcester.*	Fifty English cities and towns—aver- age.†	Dantzic.‡	Berlin.§
Total solid matters in solution, .	58.96	25.35	72.2	68.3	78.9
Total suspended matters, . . .	37.34	21.16	44.69	58.2	51.
Organic nitrogen, ...	—	—	2.205	1.16	1.23
Total combined nitrogen, . . .	—	—	7.728	6.48	—
Ammonia, ...	2.72	1.876	6.703	6.46	—
Nitrogen as nitrates and nitrites, .036		.134	.003	0.00	—
Chlorine, ...	18.94	4.17	10.66	6.97	—
Phosphoric acid, ...	1.69	.66	—	.26	1.58

NOTE.—The sewage of Paris contains $\frac{37}{96}$ as much ammonia, and $\frac{15}{82}$ as much phosphoric acid, as that of London, according to Freycinet.

* Analyses by Prof. Wm. Ripley Nichols.

† Analyses by Dr. Otto Helm.

‡ Analyses by the Rivers Pollution Commission.

§ Analyses by the Royal Commission.

Precipitation by chemical processes was referred to by Hoffman and Witt in the report of the Metropolitan Main Drainage Commission, in the following language, which fairly represents the opinions reached in France, Germany and England.

"The problem of profitably recovering the valuable constituents of sewage remains, up to the present moment, altogether unsolved; and very faint indeed are the hopes that the progress of chemical discovery will supply the means of so doing. The valuable constituents of sewage are like the gold in the sand of the Rhine: its aggregate value must be immense, but no company has yet succeeded in raising the treasure."

In the present state of chemical science, then, irrigation must be said to be the only method by which we can hope to get satisfactory results in purifying our sewage.*

In our seaboard cities, this is not at present advisable; nor is it necessary in cities like Springfield, which are situated on large rivers; with others of our cities and towns, the case is

* During our winters, the most successful of the precipitating processes could not be otherwise than enormously expensive, beside being otherwise unsatisfactory in its results.

different. The present condition of Woburn and Worcester, for example, demands some remedy; other cities and towns are likely to be soon in similar positions. Filth in our rivers is certainly "matter in the wrong place"; but in and near our houses, contaminating the soil, and water, and air, it is in a much worse place. Neither evil is necessary.

If irrigation with sewage, on a large scale, has been uniformly unprofitable in other countries,* it is likely to be still more so here, considering the length and severity of our winters and the greater dilution of our sewage. In spite of all this, it has been seen that mistakes have been made, in England and elsewhere, that we may avoid; and while there are many facts which lead us to believe that sewage-irrigation on a large scale may be carried on in our climate without much pecuniary loss, we must acknowledge that this is a matter which can be decided only by actual trial, and that the experience of other countries will not decide all the difficulties which may arise here.

It is but fair to say that many competent investigators consider the question of sewage-disposal still unsolved, and fully expect that chemistry is yet to come to our relief. If, however, as a distinguished authority has said, fourteen years of research are required for each new discovery in science, we should not be justified in suffering a great evil to go without remedy, in anticipation of an event which may not occur in this generation or the next.

The Conditions of Sewage-Farming.

The conditions of successfully managing sewage-farms are, with some modifications, essentially the same in all countries. Differences in climate, amount of rainfall, composition of the sewage, character of the soil, etc., will naturally occasion varieties of practical difficulties, which will be met in different ways in different countries and in different parts of the same country. For general rules in this matter, we cannot do better than refer to that nation which has had the largest

* In 1873, the English government published a return of forty-four cities and towns, which were purifying their sewage by irrigation, through loans from the general treasury. Not one was found to be paying all expenses.

experience, and we therefore quote the First Rivers Pollution Commission,* of England, as follows :—

“A sewage-farm requires special and peculiar management; the operations should be specially adapted to this mode of culture, and then it will be found that any land may be improved. The operations do not turn clay-lands into swamps, though sixty inches in depth of sewage are added to the rainfall.

“The dressings with sewage must be even, and at regulated intervals. In all cases, sewage should be used fresh; that is, before putrescence has set in, so as to prevent any effluvium arising from the irrigated land.† Where this is the case, there cannot be any just grounds for complaint.

“Where clay-lands are irrigated, and the contour of the land will admit of the operation, a second and even a third use of the water may be made with advantage.

“Sewage-irrigation works cannot be too simple in their character; the application should be by surface-carriers, not by underground piping, and hose, and jet.

“Land which has been worked in ridge and furrow, will require levelling; that is, the soil should be stripped, and the ground be broken up, so as to bring the surface even.

“Main carriers should be laid in nearly level lines, so as to command the area below, and secondary carriers, from half a chain to a chain apart, should contour the entire surface. The main carriers may be covered in, having valves or sluice-boards, of an inexpensive and simple kind, to retain and let out sewage as required. The main carriers will be of brick or of earthenware pipes, in size proportioned to the volume of sewage to be distributed. Conduits below eighteen inches in diameter may be made most cheaply of earthenware pipes; brick-work may be cheaper for conduits of larger cross-sections.

“Small carriers may be formed of small agricultural tiles, but jointed and laid only three parts in the soil, so that one tile, or more than one tile, can be removed temporarily at any point to allow of surface-overflowing at such points when the tiles are removed for this purpose. All ordinary conduits may be open trenches, readily formed by hand-labor or by the plough. These subsidiary contour-gutters must not necessarily be looked upon as permanent.

“After one sowing of Italian-grass has run its course (this

* Second Report, pp. xv. and xvi.

† Putrefaction also lessens the value of sewage as manure.

should not exceed two years), these minor conduits may be ploughed up with the rest of the land. Some farmers will probably clean the land by taking a root-crop off it, and then lay it down again for a second course of Italian rye-grass, and so on.

“Proper irrigation and cultivation neither fouls the land nor exhausts it.

“Where sewage-irrigation is the cause of a nuisance, it will be found either to proceed from use of old and putrid sewage in large and foul, open, ditch-like carriers, or from open tanks and large carriers being allowed to become foul.

“A sewage farm not only requires a peculiar mode of cultivation, but also special management in dealing with the produce. Tolerably good land, under sewage, will produce from five to seven crops of Italian grass per annum, weighing, in the aggregate, when green, from fifty to sixty tons per acre. A first cutting at Worthing, in May, 1865, was from twenty to twenty-five tons per acre.

“The grass is used to best advantage on the day it is cut, and is most profitably applied to stall-feeding dairy-cows. With such rapid growth and weight of grass, a special market for the produce of the land must be provided to prevent waste, failure and disappointment; but, as milk and butter are a necessity, and as good milk and butter will command a preference in the market, there need not be any difficulty with a sewage-farm because of its great productiveness. This has been, however, a complaint made against sewage-irrigation in some places; a market did not offer means for immediate sale, the grass spoiled in keeping, and therefore the experiment was pronounced a failure.

“In course of time, sewage-farming will become a special business, and when it is found that there is more profit in a sewage-farm than in an ordinary farm, the system of sewage-irrigation will have been solved.

“Where there is sewage there must be population. Milk, butter and beef will, therefore, be in proportionate demand; so that, when the true use of sewage is understood, that which is the cause of nuisance, by being wasted, will be turned to profit on the land.”

In preparing these notes, it has been the endeavor, so far as possible, to get information at first hand. Most of the places described have been personally visited, and generous assistance has been most readily given by physicians, engineers and others, for which the writer desires to express his acknowledgment and cordial thanks.

IV.—SUMMARY AND RECOMMENDATIONS.

From all the cities, and from one hundred and sixty-nine of the towns in the State, we have received replies to our circulars. As a rule, towns not reporting are very small, and dispose of their refuse in the rude and unsatisfactory method common in country places.

Eighty-seven cities and towns report more or less offence from incompletely removed sewage; in twenty-four of them disease is supposed to result therefrom; and in eight it is the *suspected* cause of disease.

Forty-eight cities and towns, with an aggregate population of 969,921, have introduced partial or complete water-supplies, while only twenty-four, or one-half of them, have provided even partially for the proper removal of such large quantities of water by sewers. Of these twenty-four, six cities have sewer-outlets into salt-water; six cities and towns into tidal streams, and twelve into fresh-water.

Forty streams and eleven ponds receive sewage, either by direct or indirect drainage into them. Forty-six cities and towns report that their present methods of dealing with sewage are objectionable; and the evils of these conditions are rapidly growing. Nineteen report that their sewage seriously pollutes the atmosphere. One hundred and twenty-eight towns have wet or damp cellars; that is, they are suffering from the want of proper drainage of the soil.

In all of these cases, the law fails to provide a prompt and effectual remedy. In two instances in this country,—namely, in Worcester and in Baltimore,—damages have been paid for the nuisance or injury caused by the pollution of streams; but the process is so slow and cumbersome, and often attended with so much personal feeling, that individuals and towns seldom seek redress in that way.

In the Miller's River Basin, the nuisance became so intolerable to so large a community, as to require special legislative action for its removal. The abutters on the Broad Canal in Cambridge have obtained an injunction from the supreme court, forbidding the city of Cambridge from discharging their sewage into that stream, to the great injury to health and property in that vicinity; and an intercepting sewer is building out to deep water.*

The most wide-spread evil in our State brought out by these investigations, is dampness of soil arising from incomplete *drainage*; that is, removal of water from the soil.†

The remedy for this condition is, in scattered communities, chiefly in the hands of individuals, and consists in thoroughly draining all soil near dwelling-houses by porous pipe-drains. In cities and towns, the same end is often attained in laying ordinary sewers, whose chief object is the removal of refuse, but which, as almost universally built, serve also for removing surface-water and a certain proportion of the water in the subsoil.

A large part of the filth in our State contaminates the air and the soil, and often the water which is used for domestic purposes, by being thrown upon the surface of the ground, or collected in loose-walled vaults and cesspools. The evil sometimes appears in a different form, when filth finds its way into small streams. The remedy for this condition of things must be governed by local circumstances affecting each case. Neither all towns nor all individuals can always afford to have what is absolutely the best means of removing refuse, and which consists in well-ordered water-supplies, water-closets, sewers, and proper methods of disposing of sewage. This is too costly to admit of universal application.

* It may at any time become an important question to an individual or a community, what protection the law affords against the fouling of one's water-supply by others. In the present state of the law, it can only be said that each case must be decided on its own merits, under the common law. The English reports give many instances of injunctions granted to restrain the pollution of streams from the year 1338 A. D. down, but no instance of an award of damages for injury from such pollution. In the United States, however, there have been instances of award of damages in such cases.

† Compare Mr. Kirkwood's Report, p. 152; Dr. Winsor's Report, pp. 227; 228; also a Report on "Drainage for Health," by H. F. French, in the Fourth Annual Report of the State Board of Health.

The substitutes for water-closets are fully discussed by Dr. Winsor. The objects to be attained by them may be briefly said to be,—

1. Frequent disinfection with dry earth, and prompt and complete removal of all excrement.

2. Disposition of slop-water in such a way that it cannot putrefy and contaminate the air in the neighborhood of dwelling-houses. This is well attained by a system of irrigation* used by Mr. Rogers Field, of London, and in successful operation in Newport† for some years past, in the hands of Col. G. E. Waring, C. E., with the simple drawback that care is required in cleaning the pipes each year. It might be successful, also, in the climate of Massachusetts.

Where this cannot be done, the safest way is to dispose of slop-water on the surface of the ground, not near dwellings, where the organic matters in suspension and in solution will be taken up by vegetation. This method would be attended with difficulties during the winter months; but they are not insurmountable. All tanks, reservoirs, cesspools, etc., for storing liquid or solid refuse, must be always looked upon as likely to cause serious trouble under the immense majority of circumstances.

Where water-supplies have been introduced, sewers should be built coincidently, or follow immediately afterwards. The only alternative at all satisfactory consists in having tight cesspools, emptied frequently by an odorless process.‡ In Paris and in some other cities, such cesspools have existed for many years without other serious ill result, except at rare intervals, than in the great nuisance and in some cases disease caused by the process of emptying them, many of them being in cellars and narrow yards or courts. In Cincinnati and Baltimore, loose-walled cesspools are common. In both cities a serious amount of pollution of the soil is said to have already taken place. That this pollution may exist to a great degree in a city where the death-rate is low, as in London, is true; but there are so many sources by which putrefied organic matters from them may get into the water

* Second report of the Medical Officer of the Privy Council, new series, London, 1874, p. 233.

† See page 334.

‡ See page 188.

we drink or the air we breathe, that cesspools should be tolerated only in case nothing better can be got. Legislation on this subject we should not consider at present expedient.

Many small streams in the State are used for the overflows of cesspools, or for the direct emptying of house-drains. Wakefield presents a considerable degree of illness and some mortality, a part of which it seems fair to attribute to this cause. In Chicopee, the amount of illness has sensibly decreased since the conversion of such a stream into a covered sewer. We must wait for the experience of several years, however, before we can speak conclusively on this point.

Even if there were no danger to health, as there must be in some cases, from the use of small streams as open sewers, they should not be used as such on account of the offensive odors arising from them. If they are covered, there are other difficulties; for they pollute the soil if built up of loose walls, and if tight they lose to some extent their power of draining the soil. Unless they are of enormous size, too, they are liable to be flooded in case of a storm, while they are during drought nearly empty, and receptacles of sewer-gases. When it becomes necessary to convert such streams into sewers, the walls should be made tight, and porous drains should be used in conjunction with them for rapidly removing the water from the soil.

Water-supplies necessitate sewers; and sewerage-systems in most countries involve pollution of streams. Offensive as this pollution may be, it is less dangerous to health than retaining filth about our dwellings in vaults and cesspools.

In Salem, Lynn, Haverhill, Worcester, and Boston, with its adjacent cities, the nuisance from putrefying sewage incompletely removed has become a serious evil. The remedies must be determined in each case by careful especial study by experts. We can only say that the principle should be established that each community should dispose of its own filth without allowing it to be a source of offence to others. In the seaboard cities, some modification of a system of intercepting sewers will probably prove the most ready solution of the difficulty. In inland cities and towns, irrigation would be likely to be successful, and not involve a large annual cost;

after some experience, it is very likely that even a profit may be realized from it.

The facts that the pollution of rivers is a growing evil, and that irrigation with sewage is the only remedy which promises well, should make it of the greatest importance that the experiment should be tried, on a small scale at first, so that some definite results may be got for future legislation.

With our hot and dry summers, it is possible that irrigation will be nearly if not quite as successful as in England, in spite of our greater rainfall, and the greater dilution of our sewage.*

Winter-irrigation will undoubtedly present difficulties which can be fully met only as experience teaches us what is best. The experiments made in Augusta, Maine, show that a small amount of sewage, at least, may be successfully disposed of upon the soil during the winter months.†

This process of irrigation seems the only practicable one for Worcester, and may be the best for Woburn. For the former city, Mr. Phineas Ball, C. E., has proposed that the sewage be carried down three miles and utilized upon the loose gravelly land there. It could be distributed by gravitation, and there is so large an area of land that the sewage could probably be disposed of to advantage, even in wet seasons. Pumps and deep drains would not be needed. There certainly seems to be no place in the State where the experiment could be so fairly begun, and the present condition of the river calls for some remedy. We reproduce Mr. Ball's map,‡ with his permission. The area included within the dotted lines represents 840 acres, a very large part of which is available for sewage-irrigation by gravity-flow.

The sewage of Woburn could be well disposed of by Mr. Bailey Denton's system of intermittent downward filtration, combined with irrigation; or it might be carried out to deep water, but probably at greater expense.

* The average annual rainfall in most parts of England is about twenty-five inches; in some parts of the kingdom it is three times as great. In Massachusetts it may be said to be between forty and fifty inches. Our sewage is nearly twice as dilute as that of most English cities.

† See page 395.

‡ From a Report upon the Possibility of Utilizing the Sewage of the City of Worcester, 1873. See also Mr. Ball's letter upon the same subject in the Fourth Annual Report of the State Board of Health, pp. 109 *et seq.*



The refuse from tanneries, which forms a large part of the Woburn sewage, is well adapted for irrigation, if diluted. After being purified, it might be discharged into the Lower Mystic Pond by an open brook. Russell Brook might be diverted to that point at slight expense.

Any discharge of sewage into Mystic Pond and into the upper part of Mystic River, can hardly fail to be a source of great offence.

Lake Cochituate is polluted, to a slight extent to be sure, by the refuse of Natick. Considering how little we know of the "germs" of disease, except that they retain their activity for a certain length of time, this must be looked upon as an ever-present danger, and should be met by legislative action. The town of Natick should be compelled to remedy the evil. If their sewage were purified by irrigation, it might perhaps pass into the Charles River without danger, and the water-supplies of Waltham, Newton, and Brookline might not be endangered, as they probably do not get their water chiefly from the river directly, but largely from deep springs or streams; but the Board do not desire to be understood as recommending such a plan.

In public institutions, prisons, asylums, etc., it is our opinion that the sewage can be utilized and purified by irrigation to great advantage, and this disposal of it should be made when the land can be got.

It is a matter of regret that there are not permanent boards of health in all our cities and towns, whose first duty it should be to give timely warning of any causes of danger to health.

The recommendations which we respectfully make are as follows:—

I. That no city or town shall be allowed to discharge sewage into any water-course or pond without first purifying it according to the best process at present known, and which consists in irrigation; provided, that this regulation do not apply to the discharge from sewers already built, unless water-supplies be thereby polluted; and provided, also, that any intended discharge of sewage can be shown to be at such a point or points that no nuisance will arise from it.

II. That no sewage of any kind, whether purified or not,

be allowed to enter any pond or stream used for domestic purposes.

III. That each water-basin should be regarded by itself in the preparation of plans of sewerage and water-supplies.

IV. That accurate topographical surveys be always made of all towns before introducing water-supplies or sewers.

V. That steps should be taken, by special legislation, based upon investigations and recommendations of experts, to meet cases of serious annoyance arising from defective arrangements for the disposal of sewage.

VI. That irrigation be adopted, at first experimentally, in those places where some process of purification of sewage is necessary ; and that cities and towns be authorized by law to take such land as may be necessary for that purpose.

VII. That every city or town of over four thousand inhabitants be required by law to appoint a board of health, the members of which shall be required not to hold any other offices in the government of their city or town.

Finally, the Board feel that, in the present state of our knowledge, sweeping laws for the general and immediate purification of all our streams would be hardly justifiable, and that they are not called for by the present condition of our rivers.

They hope to continue their investigations during the present year, for which no special appropriation will be needed.

HENRY I. BOWDITCH,
ROBERT T. DAVIS,
RICHARD FROTHINGHAM,
DAVID L. WEBSTER,
JOHN C. HOADLEY,
THOMAS B. NEWHALL,
CHARLES F. FOLSOM,

Members of the State Board of Health

JAMES P. KIRKWOOD.
FREDERICK WINSOR.
WM. RIPLEY NICHOLS.

SANITARY HINTS.

By HENRY I. BOWDITCH,

CHAIRMAN OF THE BOARD.

SANITARY HINTS.

To the Massachusetts State Board of Health.

GENTLEMEN :—I have thought that the following facts, occurring within my own professional experience, might be suggestive to some readers of the importance of attention to hygienic law about their own dwellings.

It seems to me, also, that it is expedient to keep practical questions of sanitary law and work constantly before the people.

The first statement I shall make in regard to sanitary law, as manifested during an epidemic among horses, may seem to some minds irrelevant. According to my own views of the subject, the result, to which our investigation brought us, has always been a proof of the importance of fresh air, simple food, sufficient warmth, with absolute cleanliness, not only to horses, but to man.

I must add that I think the majority of householders of the present time grossly neglect one or the other of these matters, thereby incurring greater risk of bringing disease and death into their families, than it is possible to express by any numerical formula.

I.—EPIDEMIC AMONG HORSES, AND THE INFLUENCE OF BAD HYGIENIC CONDITIONS ON THE PREVALENCE OF IT.

About thirty years ago an epidemic appeared among horses similar to, but much less severe than, that which more recently (1873) prevailed in Boston. Finding it very rife, I proposed to a class of young medical men to investigate its characteristic symptoms, and also to find out whether good, warm, and dry, well-lighted, well-ventilated, and clean stables were any more or less fortunate in the number of sick horses in them, than were those in circumstances exactly the reverse. I proposed this investigation because I supposed that valuable

information would probably be the result,—information that would be of service, not only to the animals,—at least in the subsequent treatment of them,—but also equally suggestive of hygienic law in reference to mankind. I argued as follows: The horse is one of the most careful animals we know of in the selection of his food. He uses virtually but one kind, and is very particular in his selection of that. All horses being submitted to the same kind, and nearly the same quality of food, we have an opportunity of deciding something of the effects of the surroundings of each; viz., of bad air and poor ventilation, of moisture or dryness, of light or darkness, of cleanliness or filth of their stables; and if we can find anything about these points in their influences on horses, surely we may infer something in regard to the influence of the same elements on men; because, in the grand features of respiration, digestion, and innervation, there is a great similarity between man and the horse.

Our party divided the city into certain districts, and each man inspected every stable in the district allotted to him. We obtained the number of horses in each stable, and the number of horses in each attacked by the epidemic, and, so far as was possible, the degree of severity of the disease in each stable. Moreover, we classified the stables in three categories, which might be named as follows:—

1. Excellent.
2. Imperfect.
3. Wholly unfit.

In the first we found excellent light, warmth, dryness, ventilation, and cleanliness. In the second, one or more of the above elements of health and comfort were wanting. In the third, there were none of these elements; for they were cellars, imperfectly lighted and warmed, very damp, and very dirty.

Having collected all the data, we tabulated the results.

The general—most pregnant—facts brought out by the analysis were indelibly impressed on my memory. I have acted upon them ever since. Under the influence of modern investigations in reference to “filth diseases,” they will seem most reasonable.

The three chief results to which I have alluded were these :—

1. In the best,—viz., the warm, dry, well-lighted, well-ventilated and clean stables,—fewer horses were attacked, and the disease was milder.

2. In the vilest of the stables,—those wholly unfit for use ; viz., those wanting in pure air, in light, warmth, dryness and cleanliness,—every horse was attacked, and more severe and more fatal cases occurred.

3. The stables wanting in one or two of the above qualities, though sufficiently good in the others, stood in an intermediate rank between the first and third in the number of horses attacked, and in the general characteristics of the disease. In fact, the three stood exactly in the following arithmetical proportion : Supposing 5 to represent the worst stables, in which all the horses were severely attacked, the others stood as 3 and 1. So that the numbers 5, 3, 1, since that investigation, have given to me the possible results of an epidemic of acute disease among horses under like circumstances. These results have been remembered, when watching the course of epidemics among human beings.

Cellars,—dark, damp, ill-lighted, and cold,—if used as houses, are the charnel-houses of our civilization, and are justly forbidden by law, although it is but too frequently violated in Massachusetts. These are representatives of our vilest classes of houses.

The neatly-kept, well-arranged, thoroughly-ventilated, well-drained, sunny homesteads on the hillsides of our country, can be made most wholesome in their influence upon the family. Any householder who foolishly *neglects* to provide for either of the above requisites for a house, either in city or country, tends just so far to bring disease and death into his family.

II.—TYPHOID FEVER IN MASSACHUSETTS.

In the second report of this Board,—1871, p. 157,—it is stated :—

“One section of this town is, from some cause entirely unknown, very subject to typhoid fever.” . . . “Local causes have been often sought for, but never found.”

Dr. Derby and I visited the place, and carefully examined the spot, and learned the following facts (see cut) :—

In house No. 1, D. F. had lived many years without any marked illness in his family. In October, 1857, he removed to house No. 2, five hundred and forty-three feet from No. 1, and midway up the hill, at the foot of which No. 1 stood.

The following year,—namely, in July and September, 1858,—seven cases of typhoid fever occurred in the family—the mother and six children. One of these last, it is true, did not live at the house, but was very frequently there. Subsequently, up to 1871, four domestics were attacked, and the mother had the same disease in three separate years, making in all fourteen cases, all but one in immediate residents of this house.

In house No. 3, P. P. F., son of D. F., had three cases in his family in 1868. He had his milk, and also drew water, from No. 2.

In house No. 4 resides D. B. He had milk from No. 2. Three of his children used it, and one of them had had fever a short time before our visit.

In house No. 5, occupied by T. F., 2d, nephew of D. F., three cases (1862, 1865 and 1871) had occurred. He had a cow, and used her milk. Got water in house 6, in which a fatal typhoid case had occurred, possibly contracted from milk procured from No. 2.

In house No. 6, of T. F., Sr., three cases had occurred. The house was built by the present occupant forty-two years ago. He never had fever in it till a year after D. F. built his house, No. 2,—namely, in 1862–63,—and he died of it in 1867. He got his milk from No. 2.

In house No. 7 lived W. B. F. One case occurred during the year after D. F. built No. 2, and from this latter he got milk.

In house No. 8, built forty-one years ago, resides M. M. F. In this had occurred six cases, commencing four years after No. 2 was built,—namely, two in 1861, four years after building of No. 2; one in 1868; one in 1872; and two in 1873. The last two cases had occurred in a family which had, only a few months before our visit, moved into a portion of the house. Mrs. F. had milk from No. 2; the last family had it from No. 7, or at times from the passing milkman.

This much may be further stated in regard to these houses

Plate 1.

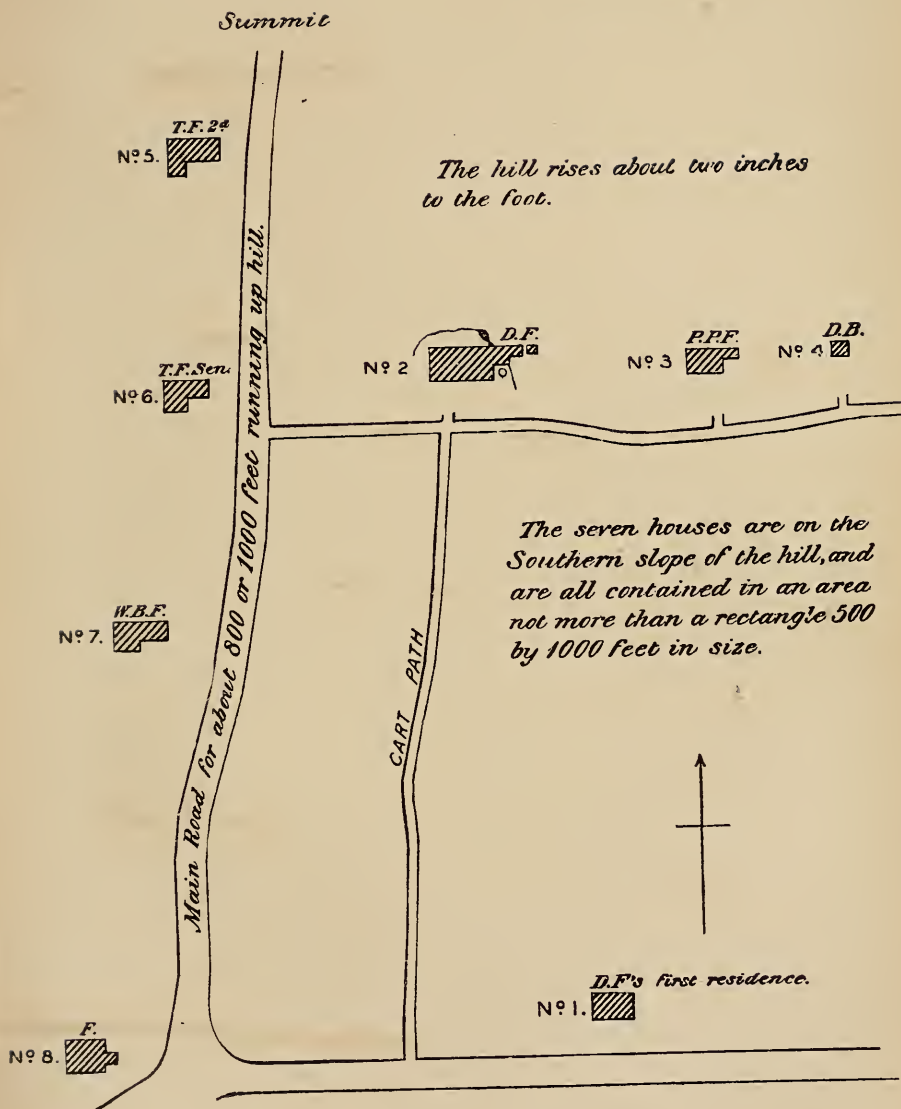
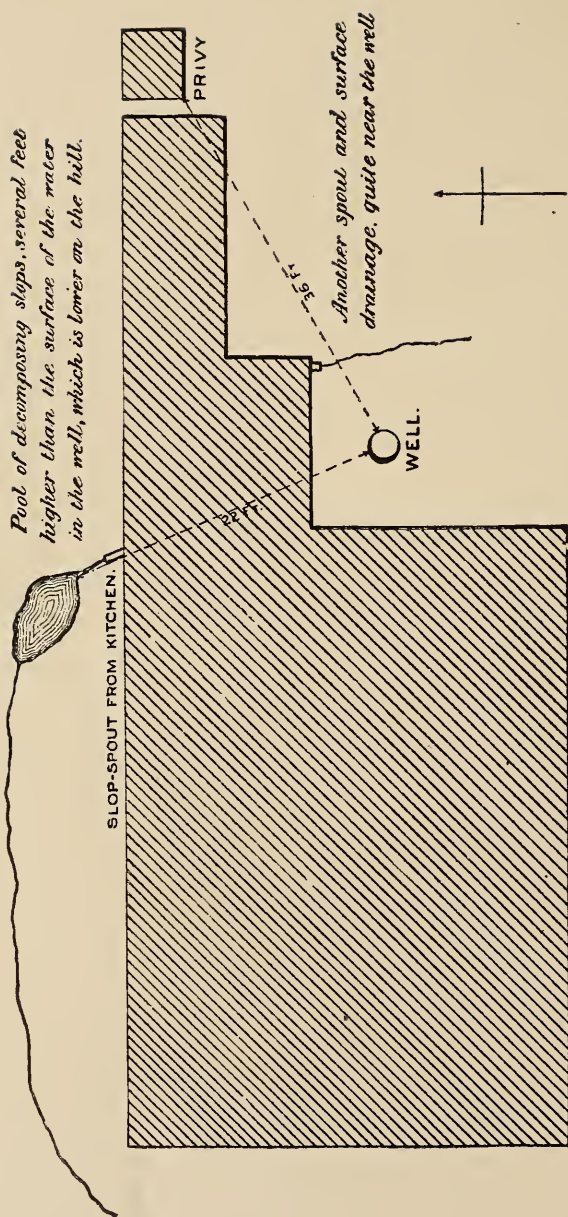


Plate 2



ENLARGED REPRESENTATION OF THE PREMISES OF D.F.

and their occupants: All of the houses are on the same southern slope, and the residents, excepting D. B., in No. 4, are relatives, and in frequent intercourse. The ground is a gravelly loam, quite shallow, supported by a very hard clay pan,—so hard that, in digging holes, the heaviest blows with pick-axe are required to penetrate it. This pan, in fact, forms a vast smooth surface, over which all water-drainage would easily flow, unless where holes are made in it. The well at No. 2 is just one of those apertures always ready for the reception of slops or privy infiltrations. The following enlarged view of the house will show this more clearly:—

The following table will also give a clearer view of the relative connection of the various houses, than can be got from the text:—

House.	FAMILY.	Gets both milk and water from.	Milk only from.	Water only.	Number of cases of fever.
No. 2,	D. F., . . .	No. 2,	-	-	14
" 3,	P. P. F., . . .	No. 2,	-	-	3
" 4,	D. B., . . .	-	No. 2,	-	1
" 5,	T. F., 2d., . . .	-	-	Keeps a cow; has water from No. 6.	3
" 6,	T. F., Sr., . . .	-	No. 2,		
" 7,	W. B. F., . . .	-	" 2,	-	1
" 8, {	M. M. F., . . .	-	" 2,	-	4
	Mrs. F., . . .	- {	From No. 5, or milkman.	-	2
					31

It will be seen from this table that every case of typhoid fever may have been, either directly or indirectly, caused by connection with No. 2. My reasons for making this suggestion (for I admit that it is not proven, and I doubt whether it is possible in such a case to present strictly mathematical proof) are these:—

It is well known from many, and especially from English investigators, that polluted water and milk may cause typhoid fever. Now, we must grant that house No. 2 has had all the requisites necessary for contamination of its well-water, and

indirectly or directly of the milk kept there. A glance at the plate proves this. Twenty-six out of the thirty-one cases were provided with either milk or water from this No. 2. Seventeen of these had both milk and water. Of the five remaining, three of them, at house No. 5, got water from No. 6, which itself got its milk from No. 2, and the two others got it at times from No. 5, where fatal typhoid had prevailed. A chemical examination of the well-water from house No. 2 revealed a certain though small amount of drainage.

But whether all these cases have arisen from No. 2 or not, the decision of sanitary law in regard to the wretched arrangements in that house, for the carrying away of its slops, and the dangers of contaminated well-water from them and the privy, would be certainly decisive against its healthfulness. It is such an imperfect arrangement as this which at times sends disease and death into our houses. A year or two since, at Mt. Desert, similar arrangements spread typhoid fever among a large number of its visitors at the chief sea-side hotel.

A thoroughly just decision would be that a well, situated as that at No. 2 is,—viz., lower on a hill than its drains and privies are,—is in a dangerous position, and, therefore, should be given up, and another sunk far from any source of contamination. If that cannot be done, the next alternative is to have all slops conveyed away by perfectly tight-tiled drains, without being left to contaminate all the surrounding ground. The privy, also, at No. 2 should have small, tightly-cemented compartments made, and earth, ashes, charcoal or other disinfectant should be thrown down daily, or, still better, thrown by each occupant of the premises immediately after leaving any refuse. All this refuse should be every few days removed and composted. Until this be done, D. F. ought to cease to allow either water or milk to be used from his premises. This was my advice two years since. I learn that it has not been followed, and, although typhoid fever has not prevailed in the locality the past two seasons, experience teaches that it is wrong to expect any long immunity from it while such conditions last. At some future time, when the people have become sufficiently educated, such a nuisance will not be allowed openly to remain a single day. Under the recent

advanced laws of England it could not now exist, unless the administrators of the law were grossly neglectful of duty.

III.—DISEASE AND DEATH IN A FAMILY APPARENTLY CONSEQUENT UPON WELL-INTENTIONED CHANGES IN A HOMESTEAD, BUT WHICH WERE MADE WITHOUT DUE REGARD TO SANITARY LAW.

Erysipelas, spinal meningitis, scarlatina, rheumatism, with sore throat, tonsilitis, fatal pericarditis with convulsions, typhoidal pneumonia,—all occurring in one family between December and the following June. Ill-arrangements of the house, defective drainage, sewage-obstruction, dampness of the cellar,—all probable factors in these diseases. Suggested improvements.

July 3, 1875, I was requested to examine a certain homestead, of which the following data were given.

The house is a fine, old-fashioned, square wooden building, midway up on a southern slope of a hill, in a thickly-settled town adjacent to Boston. All the arrangements were spacious in and around the dwelling. A large hall traversed the centre of the building, from lower floor to the garret, giving ample space for air-circulation. The soil about and above it, towards the brow of the hill, was rather damp. The house had been built by the grandfather of the present occupant, and no special liability to illness was observed on the part of the residents therein, until the time to be hereafter noticed. The cellar was not cemented, and was very damp. Across the north-eastern corner, and under the house, for the space of about twenty feet, was a drain for kitchen-slops, and for water-closet contents. The latter were first introduced into the house twenty-five years ago, apparently without evil results. The present occupant, grandson of the builder, married six years ago, and lived elsewhere, until October 1, 1873, when he came into possession of the estate. He had four children, who had been healthy. Before removing his family to the homestead, he thoroughly repaired and made very material, and, as I think, very pernicious, changes in the house. The family was in the country, and well, until August, 1874.

In the autumn, they returned to the newly-arranged home-
stead. It was heated throughout by means of a furnace. No
special effort was made to keep it either well or ill ventilated.

The disease-record that ensued, is as follows :—

Case 1. In December, 1874, four months after the removal,
the nurse of the children was taken with severe erysipelas of
the head. She was ill four weeks, and recovered.

Case 2. In January, 1875, the youngest child became
quite ill with spinal meningitis. She gradually recovered,
after many weeks.

Case 3. While the preceding was ill, her two younger sis-
ters were taken with scarlatina, about February 1. They were
ill three weeks, and both recovered.

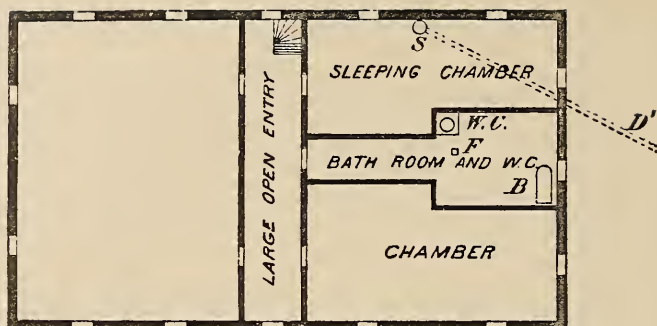
Case 4. The mother, worn down by long attendance upon
her children, had soon afterwards severe rheumatism, with sore
throat. She was ill three weeks, and confined to her bed
most of the time.

Case 5. May 1, one of the children, originally attacked
with spinal meningitis, was taken with severe tonsilitis, but
was not thought to be very ill, although feverish. She was
supposed to be getting well when she died suddenly in con-
vulsions. At the autopsy, it was found to have been a case of
acute latent pericarditis (inflammation of the heart-sac).

Case 6. This was one to which I was summoned in conse-
quence of her being affected with some acute pulmonary dis-
ease. I found her a weak, puny, apparently prostrated child.
The physical signs were scarcely perceptible, and indicated
the most trifling pneumonia at the lower part of the left lung.
Evidently something beside that was weighing down the child.
Having heard the above facts, and looked at the premises, I
advised her immediate removal. This was done soon after-
ward, and the patient slowly recovered.

It may still further be remarked, as possibly the result of
the residence, that the father, though always liable to some
throat irritation, had been during the autumn and winter
peculiarly annoyed by it. No one of the family, in fact,
escaped from some illness, and yet they had been healthy pre-
viously to living there. The attending physician had become
convinced that "something wrong existed about the house,"
and had advised a sanitary inspection of the premises. He

Nº 1.



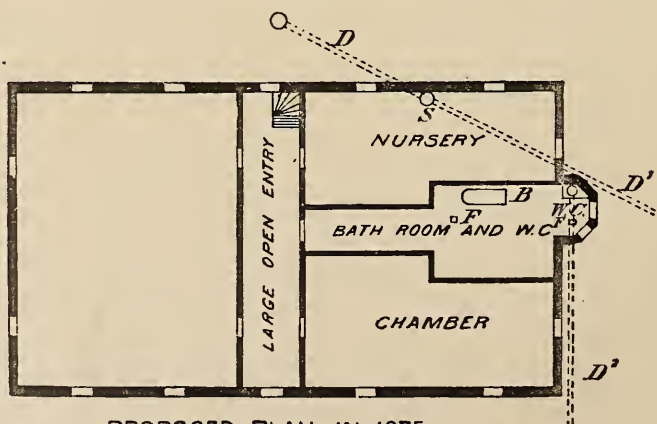
PLAN BEFORE 1873.

Nº 2.



PLAN AFTER 1873.

Nº 3.



PROPOSED PLAN IN 1875.

had made suggestions almost, if not quite, identical with those subsequently given by myself to the occupants of the house.

Let us, now, view the premises, and decide what influence, if any, they may have had upon the mass of disease which had fallen upon this unfortunate family, within a short time after taking charge of them. In order to make the subject more clear, I present the following diagrams* which may be described as follows:—

No. 1. The premises, as they had been for twenty-five years, before 1873.

No. 2. The same modified by the present occupant, in 1873.

No. 3. The same, if altered according to plans suggested by the examination.

All the diagrams represent the second floor of a large, square house, with sleeping-chambers, and bath-room, and water-closet, opening into a long entry which passes from the front to the rear of the building, thus, as stated above, allowing a very full circulation of air.

No. 1 provides that the bath-room and water-closet should be entirely separated from the two sleeping-rooms adjacent. Entrance to the two former was only by a door in the entry. A window opening on the side of the house, and a ventilator to the chimney from the water-closet, gave sufficient opportunities for the escape of deleterious gases, without contamination of the residents.

For twenty-five years these arrangements had existed, and no apparent trouble had arisen. In 1873, the grandson took possession of the house, thoroughly repairing and altering it, and in so doing—1. He shut off the water-closet, seen in plan 2, from the open window: 2. He opened a passage between the two adjacent chambers, and thus brought them into immediate contact with sewer-gases, by means of a door communi-

* The following is an explanation of the diagrams: A, a shallow hole, a few inches deep, with an iron strainer, making it look like opening to a drain. The surface of the brick-covered yard was so arranged as to convey into this aperture all the water falling upon the yard, and much from the hill above. S—Passage for kitchen-slops, and leading to D¹. D¹, a common, small, brick drain into which kitchen-slops and water-closet contents were carried. F—Furnace-flue, W C—Water-closet. B—Bath-tub. D (diagram 3)—New drain communicating with and tending to wash out D¹. D²—Proposed new drain for water-closet, and to be carried wholly outside of the house.

cating with this passage-way and water-closet: 3. By this arrangement the passage-way, connected with the bath-room and water-closet, became part of the playground for the children, and the door being frequently open, it would obviously be almost, if not quite, impossible to prevent contamination of the sleeping and waking hours of the children and of their attendant nurse. The latter, it will be remembered, was first taken ill; then came all the children and mother, successively, one of the former dying. The father had an irritation of his throat.

Now, under the light of modern sanitary investigations, I have no doubt that this arrangement was the main factor in these terrible results. But this was not all. The cellar was very damp; ashes that had been put in a brick apartment in one corner of it became a moist, decomposing mass.

This dampness was increased by the supposed drain A in the yard. This was found to be nothing but a shallow *cul-de-sac*, about a foot deep, into which all the water from the brick-covered yard, and much from the hill above, was caught, and afterwards allowed to soak down along the outside walls of the cellar, thus increasing the natural dampness of the earth near by. Moreover, I found a slop-drain at S, connected with the kitchen, running into the drain S D. Into this drain had been also introduced the soil-pipe of the water-closet. On opening the drain it was found clogged with fecal matter. Here, then, were no less than three more distinct sources of ill-health. First, natural moisture of the soil about the cellar; second, the *cul-de-sac* above named increasing that moisture; and finally, third, the fecal obstructions.

The following changes were suggested (*vide* third diagram) :

1st. Shut up the passage-way between the two chambers.

2d. Carry the water-closet fairly outside of the building into a bay window rising from the ground to the ceiling of the second story. Keep it warm by furnace-flues carried into it. Have two windows in it, and also ventilate it by a pipe carried up to the top of the house. Carry the soil-pipe into a new drain on the outside of the house at D², and thence, by a very rapid descent, into the street drain below.

3d. Build a new drain, D, from A down into D¹, to meet slop-water at S. This surface-water, thus diverted from the

cellar wall, would at times cleanse the drain, and also at times ventilate it.

4th. The cellar should be dug out, and at least a foot of clean gravel laid over the whole surface, and a strong thick cement covered over that up to a level with the surface of the ground outside of the foundations of the house. The ash-bin should be similarly cemented, and its bottom made tight.

5th. We advised a thorough cleansing of the rooms in which scarlet fever had occurred.

I trust, gentlemen, that these facts of disease, thus detailed, even if our counsel be not all that could be wished for, will be as suggestive to others as they have been to myself.

I remain, faithfully,

Your friend and colleague,

HENRY I. BOWDITCH.

NOTE.—March 1, 1876. The above recommendations, given by the family physician and myself, have been, in certain respects, more than carried out. All the soaked, filthy earth* was removed from the cellar to the depth of two feet, and after disinfecting the surface thus exposed, a layer of gravel and cement four inches thick was laid upon it. Thorough dryness of the earth is provided for by a porous drain run around the inside of the cellar walls, with an opening into a drain outside. The water-closet and slop-drains, S and D¹, are removed. The former is put in the bay-window outside of the house, with thorough ventilation by means of two shafts, one to the top of the house and the other into a kitchen flue, always kept warm. The water-closet has two windows in it, and has no connection with the house except by a door, usually kept shut. The slop-drain (S) is now a strong iron pipe, hung from the ceiling of the cellar, and carried thence into a well-trapped and ventilated drain in the

* The earth, when removed from the cellar, was so very offensive that the air was filled for some distance around it with a vile odor, distressing to the neighbors.

yard. I regret that the passage-way leading between the chambers has been retained; but as the water-closet door is kept closed, and the closet is out of the building, and so perfectly ventilated, little evil is likely to arise. The family is not constantly, as before, *necessarily* exposed to sewer-emanations. Since the recovery of the last-named patient, in June last, all have been in perfect health, except that the father has had a slight rheumatism; not enough, however, to prevent attention to business. Of course, all parties feel gratified at the result.

DEFECTS IN HOUSE-DRAINAGE,
AND THEIR REMEDIES.

BY EDWARD S. PHILBRICK, C. E.,
OF BOSTON.

HOUSE-DRAINAGE.

The following is written for the latitude and climate of Massachusetts.

It is not the purpose of this paper to prove the necessity of removing fecal matter promptly from our houses. This may be assumed as already proven. The intention is rather to point out how, in our community and under existing conditions, it can best be done. Neither does it seem worth while now to discuss the relative merits of the various systems by which this removal is accomplished in different places. Volumes have been written on this branch of the subject, and new schemes are constantly under trial. But the experience of all the large towns in this country, as well as that of most large European towns for the past ten or fifteen years, indicates the water-closet system for the removal of fecal matter, and the uniting with this of the refuse of kitchen sinks, for removal by water carriage through a system of drains and sewers to a destination suited to the locality, as best adapted to meet the wants of our people. It is, on the whole, likely to be attended with less difficulty in its details, and more efficiency when applied to all sorts of houses and all classes of population, than any other system of removal yet devised.* At any rate, this system has had a very

Limit of
subject to be
discussed.

Water-car-
riage system
an estab-
lished cus-
tom.

* Menzies, in his "Treatise on the Sanitary Management and Utilization of Sewage," page 8, says: "Looking at the question in all its bearings, I am forced to the conclusion that the water-closet system will supersede all others, while I believe that I shall be able to show that, agriculturally speaking, it is the best and most profitable."

Baldwin Latham, in his "Sanitary Engineering," page 328, says: "A good water-closet is the only appliance fit to be used within a house, for by it all matters are at once conveyed away, and cease to have the power of producing evil, so far as our houses are concerned. It is not so, however, with those systems which conserve fecal deposits within, or in close proximity to, our dwellings, as there is always danger in storing a dangerous article, however carefully we may tend and guard against its evil effects."

Mr. Simon, in his report as medical officer of the Privy Council and Local

Defects to
be pointed
out.

extensive application, and is widely popular. Until something better is devised, and has had the test of time to prove its worth, this will continue to be used. It has its weak points, however, and much remains to be done towards avoiding the dangers incident to its mismanagement, and towards perfecting its details. It behooves us, also, to seek to adapt it to the conditions existing in our community in the simplest and most efficient manner, so that they can be understood by any one who owns a house, or hires one.

DRAINS BETWEEN THE HOUSE AND SEWER OR OTHER RECEPTACLE.

Drains outside the house.

Cesspools objectionable.

The prime object of house-drainage is the removal of the refuse with all possible speed. Every device by which any part of it is hoarded or retarded in or about the premises is to be carefully avoided. Hence, cesspools are an abomination.* Wherever sewers exist, they are worse than needless. The only excuse for any sort of cesspool near a house is the need of separating grease from kitchen-drains. Small, tight, brick tanks, or stoneware grease-pots, seem to be a necessary evil among a population who waste, or whose servants waste, so much fatty matter in their kitchen-sinks as ours. The best way to provide for this will be described later.

Essential conditions.

To secure a prompt and continuous flow, drains must be smooth inside, must be well laid, of a proper size, and have sufficient slope to render them self-cleansing. Where the last is not practicable, there should be provision for frequent flushing. They should also be as nearly impervious as pos-

Government Board, London, 1874, says: "The advantages of the water-closet system, where it can be adopted, and will be properly worked, are, as regards the extremely important object of getting the refuse continuously and completely removed, too evident to require advocacy. Those advantages, however, may fail to be realized if the system be adopted without due circumspection; and the conditions which ought to be kept in view in order to avoid any such failure are, apparently, these three: First, that the closets will universally receive an unfailing sufficiency of water properly supplied them; secondly, that the comparatively large volume of sewage which the system produces can be, in all respects, satisfactorily disposed of; and thirdly, that on all premises which the system brings into connection with the common sewers, the construction and keeping of the closets and other drainage relations will be subject to skilled direction and control."

* See Menzies' Treatise, page 20.

sible, to avoid contaminating the surrounding soil. For Best material. house-drains, no material is so good as cast-iron, with calked lead joints. But glazed stoneware pipes, carefully put together with hydraulic cement, will make very good drains outside the house walls, if the soil is firm and not liable to settle. There is much of it made in this country; but it is mostly inferior in strength to the Scotch or English, which is imported at slightly higher rates. Their connections or branches Connections. should never be at right angles, but oblique, so that T-joints or branches should never be used.

They always tend to produce an accumulation of solid matter. Y-joints or branches can always be obtained (see Fig. 1 and 2), and the position of the drain can generally be adapted to their use by taking a little pains. When being laid, a swab should always be drawn through them, to wipe the surplus cement from the joint on the inside, every new piece put into the trench



Y branches.

FIG. 1.—T-joint in Drain.

being strung on to the line or rattan which carries the swab, and draws it along. The writer has seen a good drain, which would otherwise have been successful, entirely choked by sewage accumulating against those burrs of cement inside the joints, which should have been wiped out when laid. Col. Waring recommends a hemp gasket at the joint, to prevent the cement from running through, but this cannot be applied without shortening the joint to some extent, and thereby impairing its tightness. The lap is never very long, at best, and cement is never so sure of stopping water as when its surface is wiped, while fresh, on the side where the water seeks to enter it.*



Inside joints.

FIG. 2.—Y-joint.

A frequent mistake is made in laying too large-sized pipes for drains, arising from the notion that small pipes are more likely to be choked. The fact is, that all increase of size above the requirements of capacity is an actual injury, by diminishing the scouring power of the current; so that, if laid

Drains often too large.

* A gasket, carefully applied, would tend to hold the ends concentric, and insure a continuity of the interior lines, but it should be applied with skill, and in limited quantity.

Size of
drains.

When used
for rain-
water, this
governs the
size.

with a fall of two feet or more in a hundred feet of length, a four-inch pipe is better than a larger one for a house-drain used by some fifty persons, because, with this limited flow, the small one would scour better than the larger one. If rain-water is admitted from the roof-gutters, either for convenience or flushing, a larger size is perhaps needed, but six inches is ample, even then, for any ordinary house-roof. If the fall is less than two per hundred, flushing may be needed. Latham says that, in order to be self-cleansing, the house-drain should convey its contents at the rate of three feet per second. To attain this velocity, a four-inch drain must have a fall of about one in a hundred, and a six-inch drain must have a fall of about one in a hundred and forty, even when half-full. As such drains seldom run half-full, they cannot be relied upon as self-cleansing, unless laid with nearly double the above rate of slope,—say two per hundred for four-inch drains, or one and a half per hundred for six-inch drains. For hotels and large establishments containing many receptacles for sewage and many branch drains, a six-inch pipe would be ample, unless rain-water be admitted from extensive roof-surfaces. In this case the size of the drain is governed—first, by its rate of fall, which is generally limited by local topography; and second, by the size of the roof to be drained. In our climate, a rainfall of at least one and a half inches per hour from the roof-surface should be provided for, adjusting the size of the drain to carry this rainfall. In such cases, the sewage can be practically ignored, for its volume is quite insignificant in comparison with that of the rain-water. The problem then becomes a question of hydraulics, and reference must be had to the governing elements and well-known physical laws, thence computing the required size.

Drains are not intended to carry broken crockery, old clothing, rags or shoes. Such things are often found in them, it is true; but increasing the size of the drain is no remedy for such abuse, which would choke a street sewer. On the other hand, the smaller the drain which will carry the largest flow with which it is likely to be taxed, the better is the scour, and the more likely it is to keep clean. Any accumulation of sewage in the pipes is sure to decompose and give rise to abundance of poisonous gas, which it is next to impos-

sible to keep out of our houses. It cannot be expected that the interior of sewers and drains should always be free from such gases, but it is by all means desirable to reduce their volume to a minimum, and then to apply all possible precautions to prevent their mixing with the air we breathe. To prevent their access to our houses, traps are used. To a certain extent, and in certain places, they are essential, but there may be too many traps. Every trap in the line of a waste or soil pipe is necessarily a place for sewage to be arrested temporarily, and, if the use of the pipe be not very frequent, decomposition occurs, evolving gases.

Sewer-gases to be shut out and diminished in volume.

Traps.

In all houses draining into sewers, the place where a trap is most essential is outside of the house walls, on the main house-drain, after it has collected all the branches which are tributary to it, and between this point and the sewer. Prof. Edmund Parkes, in his treatise on practical hygiene, says, page 343: "It is hardly possible to insist too much on the importance of this rule of disconnection between the house-pipes and outside drains. Late events [supposed to be the illness of the Prince of Wales] have shown what a risk the richer classes of this country now run, who not only bring the sewers into their houses, but multiply water-closets, and even put them close to bedrooms. The simple plan of disconnection, if properly done, would insure them against the otherwise certain danger of sewer air entering the house. Houses which have for years been a nuisance from persistent smells, have been purified and become healthy by this means." The medical officer of the Privy Council, London, says: "This condition ought to be insisted on: that every private drain be properly trapped and ventilated in relation to the common sewers," etc. (Report of 1874, p. 32.)

In England and other places having a mild climate, it is usual to disconnect the house-drains from the street sewers by providing that the former should discharge their contents into a chamber or tank, open at the top, just outside the house walls, into which the rain-water spouts are often turned. The rigor of our New England winter prevents our people from following many of the devices which in Old England are quite efficient, and this one among others. All out-of-door drains are here of necessity kept deep in the ground, with as little

Traps between house and sewers.

exposure as possible to a temperature of 40° Fahrenheit below freezing, which sometimes prevails for several successive days.*



FIG. 3.—Trap for Drain.

The best sort of disconnection we can apply, is to introduce a pipe-trap between the house and the sewer. This should not be a built chamber with square corners, which might collect solid matter, but a mere depression in the pipe itself, having the same sectional area as the pipe, and therefore containing the minimum of matter for decomposition. (See fig. 3.)

Such traps may sometimes be forced by the compression of air in the street sewers, especially if these are tide-locked

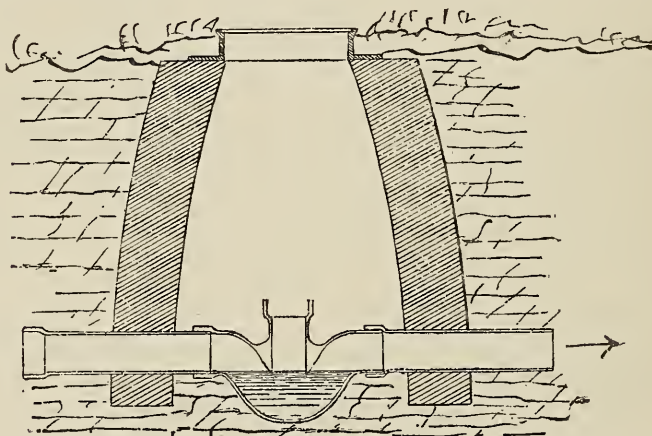


FIG. 4.

Vents for
outside
traps.

at high water, like many of those in Boston. To provide against this, a vent-pipe, of four inches diameter at least, should in cities be led from the hole in the trap directly up the side of the house, like a water conductor, and above all dormer windows. The water conductor itself will not answer for this purpose, for the compression of air in the sewer is most likely to occur during a heavy rain, when the water-spouts are fully occupied as such, and are, therefore, incapable of giving vent to the gas, for which special outlet must

* At the moment of writing this, November 30, 1875, the thermometer has averaged only two degrees above zero, Fahrenheit, for the past twenty-four hours, with a gale of wind from the north-west, forcing the air into every crack and cranny of our houses.

be given. In suburban districts, a vent into a pile of loose stones, or a man-hole chamber under ground will answer. (See fig. 4.) During the winter this chamber may be filled with dry leaves, etc., and the vent covered with wire netting, in order to prevent freezing.

A perfectly ventilated system of sewers would doubtless render this vent-pipe needless; but few of our towns, if any, have attained this stage of perfection in this respect. The method of sewer-ventilation advocated by Baldwin Latham, and largely practised in England, and by J. H. Shedd in this country, consists of small holes in the man-hole covers in the streets. In our climate, such vents are completely sealed by ice or frozen mud for six months, and perhaps by liquid mud and dust for a large part of the other six, unless cared for by men kept for the purpose.

Sewer-ventilation generally imperfect.

The subject of cesspools has been alluded to above. Even where no street sewers exist, the cesspool may sometimes be dispensed with. Col. George E. Waring, Jr., in a series of excellent articles lately published in the "Atlantic Monthly," tells of his own experience in distributing his sewage through the soil of his lawn by porous pipes, serving to utilize the material in the simplest and cheapest manner. The writer has pursued a similar plan for over twenty years successfully. But many people have too little land about their houses to provide even this small "sewage farm" within their own limits.

The cesspool, then, in the absence of sewers, becomes a necessity, and large numbers of our people are thus driven, by the increase of population, to live on quarter-acre lots, and even smaller ones, with their old privy-vaults, cesspools and wells for drinking-water within one or two rods of one another! The habits of our people demand all "modern conveniences" inside their houses. They ask for water-supply and waste-pipes in all directions, and upon every floor; but if dependent upon wells for their drinking-water, these sources are sure to become sinks in the course of time. Neither can they expect any warning, appreciable by the senses. The change is insensible and invisible. The well-water may look as pure as ever, and taste as cool and refreshing, and yet contain the seeds of disease. Some argue

Poisoning of wells.

that because their cesspool is on lower ground than the well, the latter cannot be affected, for, say they, "the dirty water can't run up hill." They forget that the contents of the cesspool may be twenty or thirty feet higher than the bottom of their well, from which they generally get their supply, and that although underground drainage, which supplies the well, generally runs in a direction indicated by the slope of the surface, there is no certainty about its always being so. There are times when the well-springs are low, and but little water is found in them. How do they know, then, that the cesspool, though in ground lower than the top of the well, may not soak in the direction of the well, whose bottom, nearly empty, is many feet below it? If the soil be once polluted about the house below the absorbing powers of surface vegetation, whose roots seldom go deeper than one or two feet, it never can be relied upon again with safety for the filtration of water for drinking.

The accumulation of filth in the soil around these porous cesspools is just as certain as the annual rise of the streams after the winter rains, and such accumulation is as certain to be followed by injurious effects upon the health of people whose houses are near such influences, as is any other violation of sanitary laws. It is said to be the invention of the shirt that brought us immunity from the plague, through the improved cleanliness of the skin. But if our people go on as they have done to pollute the soil about their houses by using water, as they now do, to dissolve their filth, rinse it out of their houses, and soak it down into their soil, the most frequent changes of linen will not save them. They must invent some other source for their drinking-water, than to pump it up again from the same soil, or the plagues of the East will visit us again in some form or other.

Sewerage
imperative
with an
abundant
water-
supply.

SEWERAGE should follow immediately, or be provided simultaneously with water-supply. For, if wells are abandoned, and aqueduct water is to be substituted, the consumption of water is multiplied at once, and cesspools become quite inadequate to dispose of the house-washings. If sewerage is not provided simultaneously with a water-supply, the surroundings of our houses soon become saturated with water as well as filth, and steam up, under our July suns, to infect

our systems, through the lungs instead of the stomach, with consequences quite as fatal, and probably more speedy.

The details of the construction of sewers, and the ultimate disposition of the sewage, are subjects demanding a separate study for each new locality, and their investigation would be beyond the limits of this paper. No branch of civil engineering is more important, or more fraught with difficulties demanding skill and a careful study of the experience of others. It is, in fact, one of the most important questions connected with the growth of our modern civilization. No community can afford to ignore it.

Trouble often arises from the settling and breaking of house-drains, when laid upon filled land. The books say that they must be laid in "virgin soil." It might puzzle the wisest to find any soil to answer that description among the many thousand houses built upon pile foundations in Boston and its suburbs. The occupants of such houses at the South End of the city, and in the fine mansions on the "Back Bay" have had a good deal of trouble from this source. In fact, it must exist, in some degree, over the greater part of wards 7, 8, 9, 10, and 11 (old divisions). The houses being built and occupied long before the mud bottom under the filled streets has become thoroughly settled, this process of settling continues in some places for years, carrying down with it the house-drains, which are inevitably sheared off near the outside of the house walls, for these are built on rigid foundations. The immediate consequence is a leak in the drain close to the outside of the cellar wall, and in some cases, entire breach of continuity.

If leaking alone, the only warning received by the occupant of the house is in the percolation of the sewage through the wall or up through the cellar floor, for there is not one wall in five hundred that will stop it. Neither will concreting cellar bottoms stop it. The more resistance there is offered to the influx by such walls and floors, the more the filth is accumulated in the surrounding soil by lapse of time and constant leakage from the cracked drain, till the cleau, porous gravel with which the street was once filled becomes saturated with the sewage, a sponge of an uncertain extent, filled with the foulest of matter, which it is next to impossible

Drains laid
in filled
land.

Broken
drains.

to shut out of the cellars, for it is both fluid and gaseous, and penetrates the minutest pores.

Remedies.

The remedy for this nuisance is by no means simple. Wooden boxes are slightly pliable, and, if made with care, and well clamped, may answer sometimes for temporary house-drains, till the material under the street has ceased settling; but even wooden boxes cannot be bent far without opening joints and becoming leaky. If houses must be built and occupied in such places, the only sure way of constructing a permanently tight house-drain would be to drive a row of piles for its foundation, between the house and the sewer. Even then, if the sewer is not built upon piles,—and they rarely are,—the break would occur where the piles cease, for nothing else is rigid over the compressible mud of these regions. This evil is so widely prevalent, that great complaint has arisen about the drainage of those districts, the source of which is more likely to be traceable to cracked house-drains, than to any defects in the sewers themselves. It is certainly a serious matter for any one who contemplates living upon newly-filled lands. The use of cast-iron drain-pipe all the way to the sewer, with calked lead joints, is recommended by some authorities, in soils subject to settling. But even iron pipes will break, if rigidly connected, about as soon as stoneware, though, having fewer joints, they may break in fewer places. They are certainly no sure remedy for this evil. If a tight, flexible pipe could be made, it might answer the purpose for awhile, but such a thing is yet to be invented in a permanent form.*

Man-holes
for access
recommended.

A commission recently appointed by the city government of Boston to consider the drainage of that city, recommend making a man-hole for access to the house-drain close to the outside of the house wall, so as to allow of ready inspection for detection and mending of leaks, caused by settlement of newly-filled lands. This is an excellent suggestion, and if the leaks were confined to this point, would help the case materially. This point is the one where settlement is most likely to occur, and it may cover the whole trouble in a

* A flexible drain-pipe, made by coupling short joints of iron with rubber gaskets, if carefully put together, might answer for a number of years, but any packing of such organic matter is subject to decay, and then leakage occurs.

majority of cases, *if* well watched. Of course, it would need protection from frost in exposed situations. This could readily be given by filling the man-hole chamber with straw or litter.

Where a "virgin soil" exists, there is, of course, no excuse for the breaking of drains. Yet they sometimes do break, from the want of care in the laying or in packing the earth around or under them, especially where passing across the earth newly filled around the outside of a cellar wall. Such places should always be puddled with water when filling, both under and over the drains. Of course, every leak is a source of great risk, contaminating the soil in its vicinity to an extent dependent on its permeability. In short, no workmanship can be too good to be employed in laying house-drains. They are out of sight, and, therefore, out of mind. Moreover, a defect can only be detected after months, if not years, during which time the soil may have become polluted to an incurable extent, rendering a home a mere pest-house which might otherwise have been healthy.

Good workmanship is essential.

The increased use of water in our houses is justly regarded as one of the most valuable agents in raising the standard of cleanliness among the poor, and in contributing to the comfort and luxury of the more wealthy. But it must not be forgotten that it brings with it these increased risks, and demands the most careful attention; for the more water we dilute our sewage with, the further will it penetrate through pores and diffuse itself through the soil, unless securely led off in proper channels to proper places.

Increased use of water brings greater risks.

DRAINS WITHIN THE HOUSE WALLS.

The above remarks apply chiefly to the drains outside of houses. But that portion of the drain which is *within* the walls deserves still more rigid scrutiny. The soil outside has certain absorbent powers, combining chemically with the poisonous gases, or holding air in its pores for their partial oxidation. Moreover, the poisonous influences within the walls, are much more likely to be absorbed by and act upon our systems through the lungs, than those which are partially shut out by the walls, or partially diluted by the open air. A New England climate does not admit of much "fresh air"

Drains inside the house.

The poor cannot afford fresh air in winter.

inside the homes of those who cannot afford to heat it during six months of the year. The suffering from frost is immediate, leading the poor man to calk every crack, while bad air is a slow poison, warning us perhaps by the sense of smell, in some degree, yet not in the urgent manner which would lead to an appreciation of its importance. If not immediately attended to and changed, the bad air soon ceases to attract our attention through the sense of smell, and is never thought of as a serious matter by a large part of our population. In fact, they might perish with the frost if they failed to shut out the pure air, and so choose the chance of living by shutting out both frost and air together. We must therefore expect to find poorly ventilated houses among the poor in winter. The exhalations from the skin and lungs are, unfortunately, not so easily collected and got rid of as the fluid and solid excretions of the body. But in getting rid of the latter, if we do not take great care, they, too, become gaseous, and return to plague us in the air, already heavy with the vapors from the lungs and skin in badly ventilated houses. The introduction of water-closets and slop-sinks into tenement houses should therefore be guarded with peculiar attention, or the benefits to be derived from their use will be more than cancelled by the evils which may arise from their defective construction.

"Modern improvements" in cheap houses.

A great number of houses have been built within a few years upon speculation in the vicinity of Boston and other large towns by a class of professional builders who erect long blocks with borrowed money, reducing the cost to a minimum by doing the work in a wholesale way, building by the dozen as it were. Every part of the work is subjected to competition and the lowest bids taken, regardless of the reputation of the builder. The drainage and plumbing of such houses is generally calculated to please the eye by a display of marble slabs and plated mountings in convenient places; but there being no reward offered for good workmanship or good planning, neither is to be expected. It is here we find a combination of bad designs, defective work, and poor materials, with a display to catch the eye, making a sort of man-trap or whited sepulchre; for no sooner does a family attempt to use such a house as a home, and to turn its drainage into the

receptacles conveniently provided for the purpose, than we find sewer-gas diffused everywhere. The occupants of such a house would be safer, in many cases, if all their sewage were thrown into the middle of the street, or even on the sidewalks, to decompose in the sunshine, or to be eaten by the dogs and rats in true Oriental style; for the products of its decomposition would then at least be diluted and scattered by the winds, and would not be carried about their houses in concentrated form by pipes and passages, to poison the air of the bed-chamber and nursery.

Menzies says (page 13): "The gas which arises in foul drains is of a singularly light character, and has a tendency to ascend or draw towards any heated part of a house. Hence it often arises that houses in towns situated on the highest ground are more unhealthy than those in the valleys,—the foul air rises to them through the drains! As during the greater part of the year the internal temperature of an inhabited dwelling, and especially of some parts of it, is much higher than the surrounding atmosphere, it is obvious that the gas naturally ascends to the living-rooms, especially if during the winter and autumn they are warm and comfortable. These water-closets are also generally on the bedroom floor, and it is more injurious to health to sleep in foul air than to be in it during the day-time."

Lightness of
sewer-gases.

In planning house-drains, they should be got outside the walls of the house as directly as possible. In public institutions, or other large buildings, where a large number of receptacles of sewage is provided, the main drain for the collection of the whole should be outside the walls, wherever practicable, for the reason that fewer joints of pipe, and fewer chances of leakage from imperfect work, would thus occur within the walls.

Drains to be
led outside
the walls.

The material for drains within the walls should be metal in all cases. It is often customary to lead a drain across under a basement floor by stoneware pipes, which, though much better than the old-fashioned brick drain, is far inferior to iron. The writer has seen such a drain, well laid with Scotch pipe and full cement joints, and covered with concrete of hydraulic cement on the cellar floor, giving off through this cement an amount of stench that made the cellar nauseous,

Material for
drains
inside of
houses.

Cement is
pervious to
gas.

even though the soil-pipe above was ventilated. The sewer in the street may have been in fault, but this case serves to show how penetrating are these gases, and that good hydraulic cement mortar, though impervious to water, is not impervious to them. A ventilated trap outside the house afterwards stopped this nuisance in the case referred to, but even this may not be enough in all cases, for a certain amount of slime inevitably collects upon the insides of house-drains themselves, which, by its decomposition, evolves gases requiring metal joints to hold them. Menzies says (p. 14), "I have known this gas pass through floors and through chinks in two-foot walls. It will find out the smallest opening in any pipe that will give it a chance of getting to the heat or the open air." This same gas, if escaping from a slight leak in a drain buried in the soil outside the house, would doubtless be absorbed and rendered innocuous by the soil and by the air within its pores, but under a house the case is widely different. Cast-iron pipes, with leaded joints, well calked, and painted, are safe; and unless subjected to such great changes of temperature as might loosen the joints by expansion and contraction of length, will prove satisfactory for a long term of years.* If iron is used inside the walls, there is seldom anything to be gained by burying it under the cellar or basement floor. Such pipes should be readily accessible for inspection. If a little attention be devoted to the subject, they can generally be placed along some wall or partition, or hung from the ceiling, where their joints can all be readily seen to be recalked and painted whenever necessary. If a water-closet be placed in the basement, it should be near the wall, where the soil-pipe leaves the house, so that this pipe, passing just above the floor, can serve for its drainage. If necessary to this end, the floor of the closet can be raised one or two steps above the rest of the basement floor. Prof.

Sewer-gas
very pene-
trating.

Iron pipes.

Should be
above floors
in base-
ments.

* Latham, in his Sanitary Engineering (p. 319), gives preference to lead over iron for soil-pipes. But the superiority of cast-iron over lead has been amply proven in this country for over ten years. Latham's objection to the rusting of iron pipes may be applicable to wrought-iron, but does not seem valid as to cast pipes, the insides of which soon become coated with a film, beyond which the rust does not penetrate far. Lead soil-pipes, on the other hand, are very difficult to secure against sagging out of place, against rats, and against corrosion, or nails carelessly driven.

Parkes says (Practical Hygiene, p. 343): "It should be a strict rule, that no drain-pipe of any kind should pass under a house. If there must be a pipe passing from front to back, or the reverse, it is much better to take it above the basement floor than underneath, and to have it exposed throughout its course."

It has been a common practice in England to provide a drain from the cellar or basement into which the scouring water can be emptied which is used in the washing of floors, etc. This drain is generally discharged into the main drain outside of the house. A trap is generally provided under the gulley or sink where the water is poured, but, as the place is not in daily use, this trap is likely to become dry or filled with sand from the scouring water, and in either case useless. It is better to dispense with the trap in such places, and depend upon the trap which should always exist outside the house. The only risk of bad gas from such a sink, would be from the other house-drains themselves. This risk is not to be ignored, and in order to escape it, such a sink should be placed, not under the house, but in an outer shed, or, better yet, in the yard, outside the house, where a grating can cover it. A pocket or catch-basin for sand should always be provided under the grating.

Cellar and
basement
drains.

The drainage of the soil on which a house is built, if it consist of porous sand or gravel, will not require much attention, unless the level of the cellar be decidedly below that of most of the surrounding land, as in broad plains or valley-bottoms. When such cases occur, or when the soil is impervious, a porous tile-drain should be laid, three or four feet deep if practicable, with porous material over it around the bottom of the foundation-wall, with a delivery to the house-drain above its outside trap which disconnects it from the sewer. In case no sewers are provided, among a scattered population, such a drain can generally be led to some point low enough to discharge it on the surface of the same lot; if not, the lot is very ineligible for building purposes.

Foundation
and subsoil
drains.

Branch drains from sinks, wash-trays and wash-bowls are generally made of lead, which seems to be the most suitable material. Its pliability and durability are valuable qualities. The first may lead to its distortion of form, by sagging, if not

Branch
waste-pipes.

Putty joints.

well supported. Where these lead waste-pipes enter the iron ones, a common practice among plumbers is to secure the joint by glazier's putty. This is but little better than a rag packing for such a place, for the slightest expansion and contraction of the pipes, endwise, by changes of temperature, will crack the putty and lead to its crumbling away in one year. The only proper way to make such a joint, is to solder a tinned iron or brass ferule to the outside of the lead pipe, which is to enter the bell of the iron pipe. This ferule gives a stiff material against which a lead joint can be calked in the same way as between two pieces of iron pipe. This lead packing will yield to the expansion, without breaking or crumbling. When lead traps are used under water-closets, the joint between them and the iron soil-pipe should be secured in the same way.

Delivery of waste-pipes from bowls, etc.

The connection of waste-pipes from wash-bowls, bath-tubs, wash-trays, and of tank overflows, with the soil-pipes, has given rise to much trouble. In this neighborhood, it is customary for plumbers to enter them into the trap of the nearest water-closet below the water-line. This is often carelessly done, making the connection so near the surface of the water in the trap that the seal is not reliable. Moreover, the emanations of foul gas from the water in the trap would rise through the cistern overflows and render the water in such cisterns unsafe for drinking, for the rarity of the use of such overflows renders traps in them liable to dry up, and therefore of little value. The English discharge such waste-pipes over a grating in the open air, which drains into the main drain below, thus insuring complete disconnection. But this is not practicable in our climate, and we must seek some other method. The overflows of tanks must needs have open mouths at their upper ends, and should, therefore, not connect with a foul pipe below. The rain-water conductor from the roof is a fit place to discharge them, unless itself connected with the drains below. When thus disqualified, the overflows can terminate in the open air outside the house, for they will never carry water enough to cause annoyance, the water being always clean. The wastes can be safely discharged, as above described, into a water-closet or slop-sink trap, if pains be taken to enter them at its bottom, as far as possible below the

Overflows.

English method impracticable here.

water-line. If such wastes are of considerable length, say ten feet or more, they may become offensive, from the decomposition of the slime inside them in warm weather, and should have S-traps near their upper ends, with vents from the top of these traps at least one inch in diameter, connecting with the main vent of the soil-pipe. The practice of drawing drinking-water from a tank or cistern must be condemned under any circumstances. There is no reason for it, with a constant supply in the mains, such as is universally given in our country. The practice originated with the system of intermittent supply, formerly prevalent in England, but now going into disuse.

Drinking-water should not be drawn from tanks.

Soil-pipes from water-closets were formerly made of lead, at first by soldering sheet-lead into cylinder form, and afterwards by the seamless process. The first show more rapid corrosion at the solder-joint; both are subject to corrosion and sagging, and to being gnawed by rats. Iron is much safer, and fortunately cheaper also, and is therefore now generally used.

Material for soil-pipes.

Plumbers sometimes connect branching soil-pipes by T-joints, when it serves their convenience. Y-joints should always be used, for the same reasons as given above for connecting outside drains. The Y-joint sometimes requires the introduction of another small bend to complete the necessary change of direction. Hence arises the temptation to use the T-joints in contract-work, to save the cost of the bend and its application.

Y-joints, and no T's.

Rain-water cisterns are sometimes built in basements, or outside of houses, underground, having their overflows in the house-drain. Such an arrangement is never safe. However carefully the overflow may be trapped, the long drouths of our climate may dry up the water-seal, and allow the sewer-gas to spread over the water and be dissolved by it. Moreover, the drain may be obstructed below the junction of the overflow, and the whole house-sewage is then backed up through the overflow into the cistern. Such an instance actually occurred within the knowledge of the writer, where about a barrel of grease was allowed to collect in the drain from the kitchen-sink, after filling the cesspool provided for the purpose. The first intimation received of this obstruction by the

Rain-water cistern overflows.

occupants of the house was that the cistern-water, which was used through a filtering-pump for drinking, got a "coppery taste," as they expressed it. On cleaning the cistern, it was found that the whole drainage of the house had been emptying into it, apparently for some weeks. Cistern-overflows can generally be discharged on to the surface.

Receptacles
for grease.

The need of pots, tanks or other receptacles for the collection of kitchen-sink grease, has been alluded to above, and will be generally felt in all houses where the inclination of the drain is not very rapid. The writer has tried various devices for this purpose. The subject is ever fruitful of annoyance, especially among small families who employ no man-servant, and whose members dislike to meddle with dirty messes. Sufficient space must be given for the accumulation of grease during the intervals between the times of cleaning. The inconvenience of frequent cleaning in our winters, when the congelation of the grease is most rapid, and the inconvenient depth below the surface required to escape frost, have led to putting them in cellars, and even above the kitchen floor, under the sink, in some cases. The latter was found unendurable, from the stench arising when cleaned, and the frequent cleaning rendered necessary by the limited space for storage. Stoneware pots were tried, of about ten gallons capacity, both in kitchen and cellar. When in the cellar, the cleaning is less offensive; but in severe weather it is difficult to so ventilate a cellar as to keep out of the house all effluvia so arising, while their limited size requires attention once or twice every month in winter. In the days when our grandmothers presided over their houses, there was more attention given to the small economies of the household, either by those grandmothers in person, or by some servants who felt more impressed with the sin of wastefulness than do the denizens of our modern kitchens. Certainly there is a value in the grease now thrown away in dish-water which ought to lead to its being collected before going into the water, instead of encumbering our house-drains with it to such an extent as is now done. Until such an end be attained, however, some means must be provided for keeping it out of the pipes, for no matter how large these may be, if as large as a flour barrel, they would be filled solid with grease in one winter by

some sinks, even where the family consisted of but five persons, all told. The best plan yet devised for this purpose is,

perhaps, a small brick tank, laid in hydraulic cement, and plastered smooth inside, placed as close as possible to the cellar wall on the outside, with the sink as close as possible to

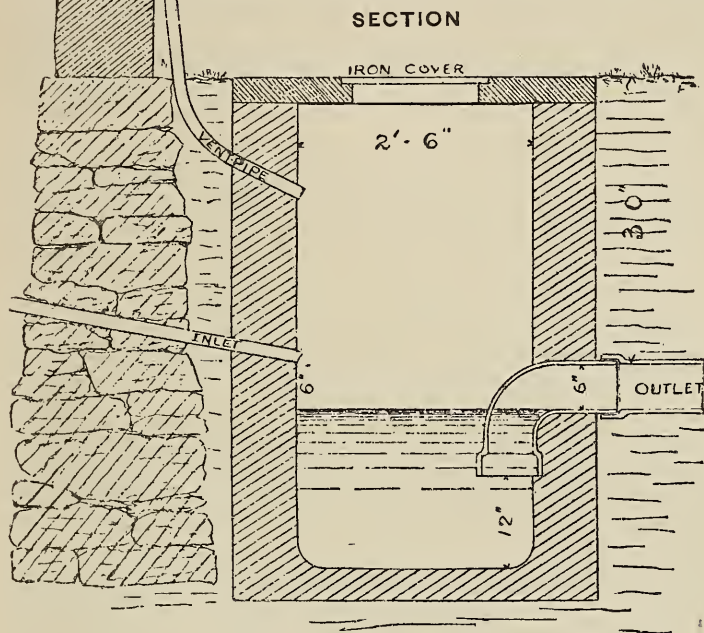
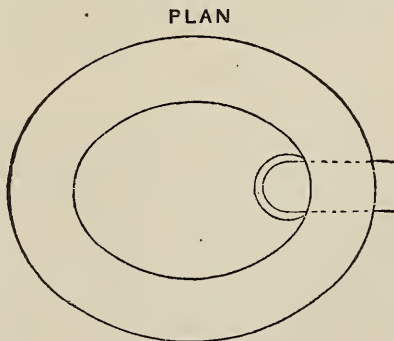


FIG. 5.—Cesspool or tank for grease.

the same wall on the inside, so that the grease shall not congeal in the pipe between the two. (See Fig. 5.) For small and medium houses it should be from one and a half to two feet square on the inside, with the bottom about two feet below the outlet-pipe, which is to turn down about a foot on the inside, with a smooth, round turn, so that its mouth may be so much under water. The inlet should be about six inches higher than the outlet-pipe, to allow the grease to collect to that



thickness above the water line, which is governed by the level of the outlet, without obstructing the mouth of the inlet. The grease will then float on the water, and become congealed in the form of a dirty scum, while the water and other matter in suspension flow out by the mouth of the outlet, about a foot below the surface. The whole must be so placed as not to freeze. The depth needed for this will depend largely upon the exposure. The walls being built to the surface of the ground can be covered with a flag-stone, with hole and iron cover.

The soil-pipes from the water-closets should by no means enter this receptacle. It should be upon a branch drain, serving the kitchen and scullery sinks alone, having its outlet into the principal drain.* If more than one sink delivers into it, the tank itself should have a vent-pipe, to prevent the air, compressed by the influx of water from one sink, from being forced up through the trap of the other inlet-pipe into the house. If the waste-pipe becomes choked with grease between the sink and cesspool, as will often happen when the fall is not rapid, it may be sometimes kept clear by flushing occasionally with boiling water, provided the passage be not wholly obstructed.

Fixtures
inside the
house.
Waste-pipes
found in too
many
places.

The demand for modern conveniences has introduced waste-pipes all over our houses. Their orifices are found in bedrooms, and on every floor, from attic to cellar. With perfection in planning, workmanship and management, such things may possibly be made safe. But we cannot expect perfection in either of these departments. The nearest approach to it ought to be looked for among the homes of the wealthy, whose means can command the services of good architects and good workmen, and who are not stinted as to the cost of

* The reason for excluding the soil-pipes of water-closets from the grease-pot or tank,—though their introduction is apparently recommended by Col. Waring, in speaking of Field's flushing-tank,—is the same as has been given against the storage of all fecal matter near a house, for however limited a period, in hot weather. Moreover, the separation of the grease is much more difficult if fecal matter be introduced into the same receptacle. Field's flushing-tank is doubtless an excellent arrangement for mild climates; but our winters would require its inlet to be placed so far below the surface, that the additional depth required to work the siphon would render its outlet inconveniently deep, except where the ground slopes rapidly, and then the flushing is of little importance, comparatively.

such appliances as conduce to safety in drainage. But it is precisely in the most costly houses that the waste-pipes are found most widely scattered. The chances of imperfect work are too great to justify the practice of putting wash-basins or water-closets in sleeping-rooms under any circumstances, or even in dressing-rooms, closets or passages leading directly from sleeping rooms, unless these conveniences are supplied with the most ample and thorough ventilation, put together in the most careful manner, and most scrupulously taken care of. English authorities say that water-closets should be built over one another in a tower projecting from the house.* The placing of one over the other is a great advantage in point of economy of construction. But the placing them outside of the line of the house-walls is hardly practicable in our climate. Our winters compel their construction, either on the south-erly side of our houses or in their interior, unless special heating arrangements are applied. It therefore becomes all the more necessary to provide special means for their ventilation.

Waste-pipes
not to be in
sleeping-
rooms.

Placing of
water-
closets.

The water-closet is used by thousands who know little or nothing of its mechanism, and who necessarily consider it as an automatic arrangement, needing little or no attention, and who therefore bestow none upon it. But, as it is no more perfect in its way than all other work of human hands, it has many faults and weak points, particularly in the form of the pan-closet, now so generally used. It therefore behooves the architect who plans a house for the rich man, the mechanic

General
ignorance as
to their
mechanism.

* See Eassie's "Sanitary Arrangements," page 62; also the supplementary report for 1874 of the medical officer of the Privy Council (England), from which the following extract is taken, page 33:—

"In considering the admissibility of water-closets, it has always to be remembered that the working of an ordinary water-closet is easily deranged, and that water-closets, when out of order, and especially if in the interior of houses, are apt to become very dangerous nuisances. The ordinary water-closet is, therefore, a thoroughly ineligible form of privy for those who are unlikely to take proper care of it, or are from poverty unable to give it such occasional repairs as it may require."

"Among such classes of population it is, of course, unfit that any form of indoor privy should ever be sanctioned; but even in the best-ordered houses the occasional danger of indoor water-closets must not be disregarded. Water-closets ought never to stand where they cannot have outside windows: they ought, if possible, to stand as projections from the body of the house, and with windowed lobbies dividing them from it."

who plans his own, or who builds to sell again, and lastly the householder and head of family himself, to know something of the general principles of its construction, and to avail himself of such knowledge in planning, building and taking care of a house. There seems to be a deplorable lack in this respect, for instead of closets and drains, placed so as to insure the getting rid of the refuse with safety, we often find poisonous gases emitted from them, and conducted all over the house, by an ingenious system of pipes, floor-spaces and partition-spaces in our plastered buildings.

Water-closets of ancient origin.

The use of water-closets dates from a very remote period. Thomas Ewbank, in his historical treatise, says (p. 561): "They are an ancient and probably an Asiatic device. The summer chamber of Eglon, king of Moab (Judges iii. : 20-25), is supposed to have been one. They were introduced into Rome during the Republic. Those constructed in the palace of the Cæsars were adorned with marbles, arabesques and mosaics. At the back of one still extant, there is a cistern, the water of which is distributed by cocks to different seats." Their general use in private houses dates, however, from a very recent period. It is to be regretted that among the hundreds of patented inventions, recently brought before the public, one of the most defective and dangerous of them all should have got into such general use in this country; viz., the ordinary "pan-closet." Baldwin Latham speaks of them in his "Sanitary Engineering" (page 329), as "cumbrous appliances, which cannot be introduced into a house without creating a nuisance." The fact remains, however, that thousands of our fellow-citizens have already fitted their dwellings with them, at a considerable cost, and it becomes important to remedy their defects as far as possible where already in use. The following devices are recommended for those who have already made this bad investment, while advising those who are building anew to adopt some of the simpler and safer inventions which will be described afterwards.

Ordinary style very defective.

The pan-closet is described in the annexed cut, figure 6, and consists of several parts: *First*, The bowl of crockery, directly under the seat. *Second*, The copper pan, which, when ready for use, is in the position shown by the dotted lines, is full of water, and seals the bottom of the bowl.

Third, The cast-iron receiver, standing on the floor, within which the pan is tilted when discharging its contents; and
Fourth, The lead trap just below the floor. Its defects are numerous, but its chief defect arises from the reservoir of foul air always present in the iron receiver below the crockery bowl. The inside of this receiver is necessarily foul. It is quickly smeared with filth when first put in use; its in-

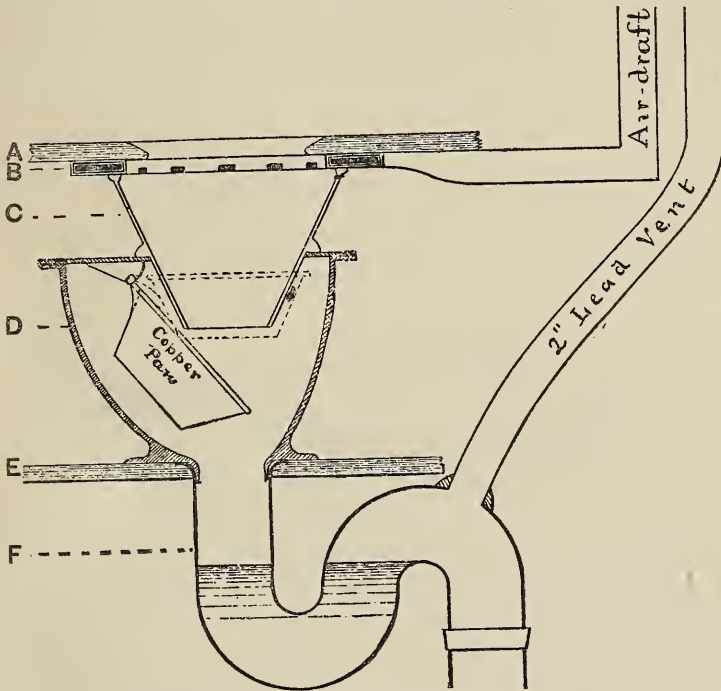


FIG. 6.—A, Wood seat. B, Annular ventilating tube. C, Crockery bowl. D, Iron receiver. E, Floor. F, Lead trap.

terior is inaccessible, and can therefore never be cleansed. Directly below it is the large metal trap, whose contents generally emit noxious gas from their decomposition, and this trap cannot be safely dispensed with. Whenever the pan is tilted and discharged, there is suddenly dropped into this receiver several quarts, and sometimes a pailful of water. This must of course displace its own volume of the foul air pent up there, for which there is no escape in any direction but upward, with a rush, past the tilted pan into the bowl, where it mixes freely with the air of the room. Various

Disinfecting
water-
closets.

schemes have been devised for getting rid of this nuisance. When not gotten rid of, the pan-closet is a dangerous neighbor. Several devices are described by Eassie ("Sanitary Arrangements," p. 74) for injecting a disinfecting fluid by an automatic apparatus into the pan or bowl at the instant of opening the valve. Such contrivances may serve a good purpose, if well regulated, but the adjustment of these additional parts, and the occasional renewal of the disinfecting agent, complicates matters somewhat, and renders such a remedy less simple and less adapted to general use than it is desirable that it should be.

Ventilating
water-
closets.

If the water-closet can be located near a chimney, which is sure to be in constant use, as the kitchen chimney, the evil can be abated by building a zinc tube of some three inches diameter into the chimney-stack, alongside the hot flue, or inserting an iron tube within the old flue, and leading its



FIG. 7.—Annular ventilating-tube over bowl.

lower end into the space under the water-closet seat. In wooden houses and other houses also, if in the country in isolated positions, windy weather often crowds air up through openings in the floor from the communicating floor-spaces, so that in order to insure that the draught of this tube may draw directly from the bowl of the water-closet under such circumstances, the tube should end in an annular flat tube of galvanized iron, to be placed directly over the top edge of the bowl, and under the seat, with perforations around the inner edge of the ring, for withdrawing the air which we wish to get rid of. These annular tubes are now made in Charlestown, and are sold and applied by most plumbers. (See figure 7.) The cover of the seat must then be arranged so that the valve can be drawn after closing such cover, and care should always be taken to so close the cover before lifting the valve. The foul air which is puffed upwards at the instant of emptying the pan is then sucked up by the draught of the chimney, without

an opportunity of mixing with the air of the room. Where no warm chimney can be had near enough to be thus used, the draught-tube can be run directly through the roof, with some ventilating attachment at its top to encourage the upward draught of air. This will often work well in winter, when the air of the house is artificially heated, and tends to escape by its own buoyancy. But in warm weather, it is not so likely to be of use. At that time the chief reliance is upon open windows and a free current of air through the house. For this purpose it is always advisable to provide at least a part of a window directly over every water-closet. The pan and hopper closets which are often found tucked into corners, under stairways, and in other dark places, without special ventilation into chimneys, are sure to become nuisances, and poison all their surroundings. It has been suggested that the iron receiver of the pan-closet should have a vent-tube between the pan and the lower trap, so as to provide for the exit of the foul air displaced by the descending charge of water. But this displacement is so sudden, and in such a large volume, compared with the capacity of such tube to receive it, that this does not appear feasible. Moreover, if the inner surface of the receiver is tapped by any sort of tube, its orifice would soon be likely to become smeared and stopped by the wet paper and fecal matter which is dashed about.

Windows
needed in
summer.

Ventilation
for iron re-
ceivers not
efficient.

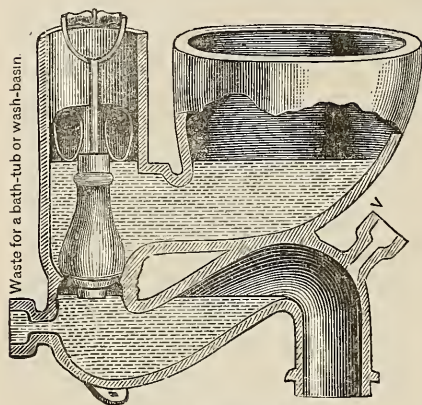
If an upward air-draught can be secured from the bowl, it is constantly at work, removing not only the foul air discharged when the pan is tipped, but all exhalations from water standing in the pan. This water is always exposed to the foul air of the receiver, around the outside of the bowl, and dissolves a certain amount of the gases from this source, to be given off and scattered by rapid diffusion in the air above, even when at rest, for the air is as a vacuum to other gaseous bodies. No vent from the iron receiver could remedy this, for that is foul past redemption. No circulation provided by such a vent could much affect the degree of its foulness.

Gases
escape
through
water by
solution and
diffusion.

The above-described defects in the pan-closet may in some degree be remedied by an efficient air-draught, in cases where this closet is already in use, but a surer remedy yet is found

Improved
water-
closet.

in another style of closet, which can be applied with little extra cost when building anew. The closet made by George Jennings of London (see figure in margin) has accomplished the much-desired end of dispensing with the pan entirely,



Jennings Water-Closet.

together with the air space between the bowl and the lower trap. It also dispenses with a separate trap below, having such a trap in itself, made in connection with the bowl, all in one piece of crockery. Baldwin Latham calls it "a perfect sanitary appliance." Its water-supply is taken directly from any supply-pipe,

adjustable to the actual pressure, so that no separate tank, or service box or valve, wires or cranks are needed. The ordinary pan-closet alone costs less than half as much as Jennings', but its cost, with all those accessories, set up in working order, would be nearly as great. A supply direct from the pipes in the ordinary pan-closet is objected to with reason from the risk of back-flow of foul air from the closet into the pipes in case of lack of water-pressure from any cause at the moment of using the closet. But in the Jennings closet this risk is entirely avoided by the construction of the valve, which is a flap-valve, made of a rubber disc, rendering all back-flow impossible, and opening only with the pressure of water. Ample flushing of the bowl is secured by having the valve worked by a float, so that it remains open till the water reaches the prescribed level in the bowl. The Jennings closet does not seem to be quite all that could be desired, but it is certainly the best thing in the market. Its weak points are,—

First. The hollow plug, made hollow to act as an overflow for possible surplus of water delivered, allows the free escape of noxious gas, if any such there be, from the contents of the trap below. The only protection against this, as the apparatus is now constructed, would be the second lifting of the handle

every time the closet is used to insure the complete expulsion of the foul matter from the lower trap.*

Second. Most of these closets in our market have no provision for a vent-hole in the trap. The necessity for such a vent was pointed out by Mr. Rogers Field, C. E.,† and a vent-hole is now provided, when demanded, by the makers at the point marked V on the diagram.

The cut should show the plug to be hollow, to act as an overflow. The draughtsman drew the plug in elevation, while he should have drawn it in section.

With this closet, the use of a disinfecting fluid, or the special ventilation of the closet-seat will probably be needless. But it does not escape the need of giving a vent to its own trap, as above described.

A copious vent for the soil-pipe itself should never be omitted.‡

Vents for
soil-pipes.

The reason for this vent is as follows:—

The main drain of the house is supposed to be provided with a large trap, outside the house, as described above. There is also to be a trap under the water-closet, or forming a part of it. Between these two traps there must always be a confined column of foul air; this column, if not connected with the outer air by a vent made for the purpose, is subject to compression or tension from the following causes, acting together or separately. Compression is caused,—

Why always
needed.

* Since the above was written, the writer learns that this defect has been entirely remedied by Mr. Jennings. He now attaches an inverted cup to the handle, just above the hollow plug, which effectually traps this air-hole. Parties ordering Jennings closets, should see to it that this important improvement is not omitted.

† The following is taken from a private letter of Mr. Field to the Secretary of the State Board of Health, in speaking of such a vent-pipe: "The function it has to perform is simply that of admitting air whenever the closet is worked so as to prevent the water being sucked out of the trap by the partial vacuum that would otherwise be created by the sudden rush of water down the arm leading from the closet to the soil-pipe. This pipe in no way does away with the necessity of having the soil-pipe properly ventilated; and, *vice versa*, the ventilation of the soil-pipe by carrying it up above the roof does not do away with the necessity of this air-pipe."

‡ Mr. Simon, in the report above quoted, says: "That every private drain having inlets within a house, must have ascending from its head or heads into some suitable high position in the open air, and where it cannot infect the interior, a ventilating pipe or ventilating pipes of sectional area amply proportionate to its own."

First. From changes of temperature, either from change in that of the surrounding air, or by the pouring of hot water into the pipe.

Second. From the blowing of air into the soil-pipe from the sewers, which may not always be ventilated, and which may occasionally find the disconnecting trap disabled from some accident.

Third. From the influx of a considerable volume of water into the column from above, forcibly displacing an equivalent volume of air.

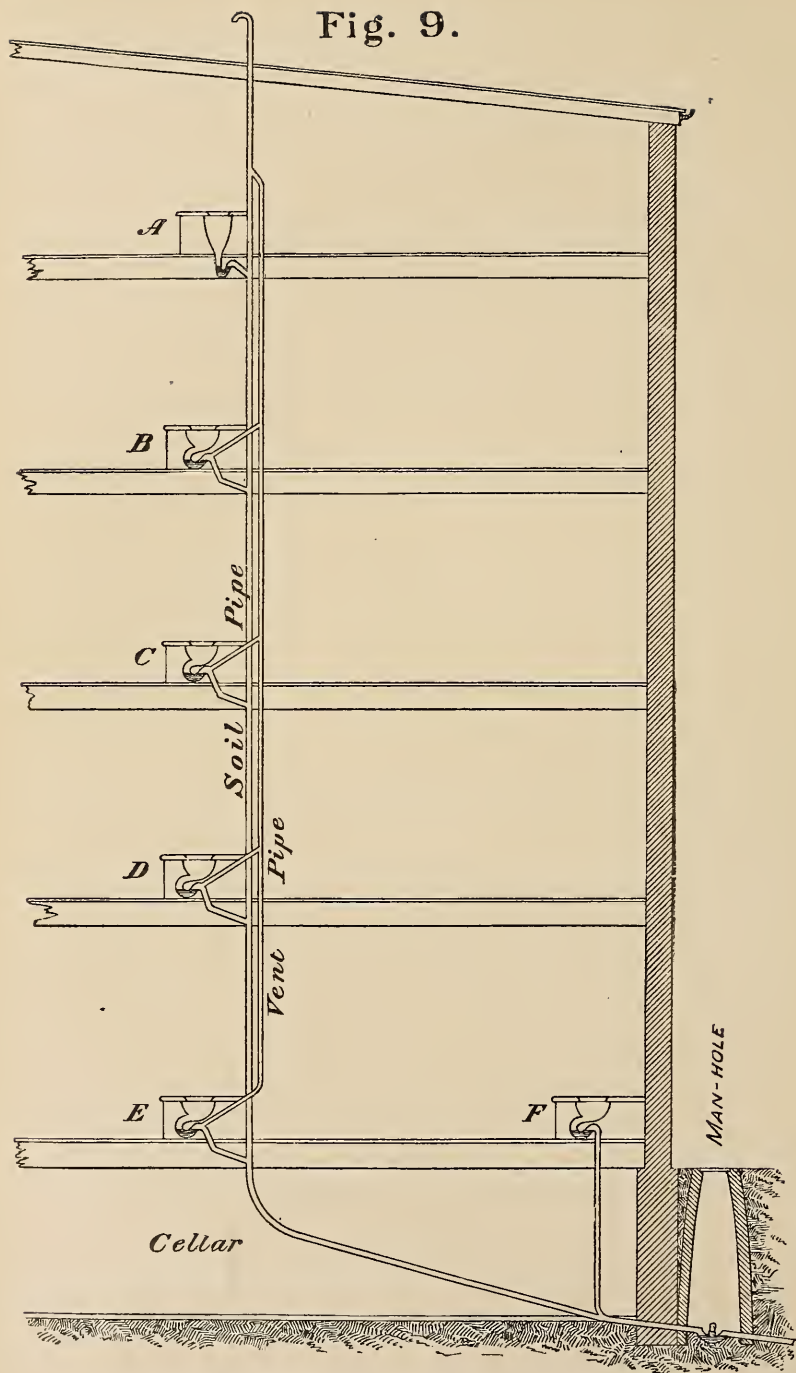
When compressed from either of the above causes, the foul air is blown out into the house at the orifice of some waste-pipe in connection, in spite of its trap.

Tension may occur from the reduction of temperature, or from the efflux of water as it leaves the confined column through the outside trap. In either case the vacuum is supplied by sucking the water out of some of the connecting traps, leaving their waste-pipes unsealed. The remedy is simple enough, and is often applied now in new buildings by carrying the soil-pipe up through the roof, with an open end, to connect the interior with the open air. In small houses, having but one or two water-closets, it will answer the purpose to apply a two-inch lead or iron pipe, to run from the top of the trap of the upper closet, up through the roof. If, however, the outside disconnecting trap is not ventilated, as above recommended, and if such small houses empty their drain into a public sewer, *nothing less than the whole size of the soil-pipe will be safe for its vent.* In building new houses, it is recommended that the soil-pipe be carried beyond the roof, and of its full size. If the sewers are ever tide-locked, a heavy rain at such times displaces an immense volume of air, which is forced into the house-drains, causing these vents to be fully taxed.

Soil-pipe to
be carried
up through
roof.

Where several water-closets are placed one above another, on different stories, drained by a perpendicular soil-pipe, as often occurs, it is not enough to extend the soil-pipe up through the roof. The trap on each of the closets below the upper one, except perhaps the very lowest, if this be at the bottom of the column, must have its own separate vent, otherwise the rush of water down the column from the upper

Fig. 9.



story, or from any of the closets above the lower one, will be likely to siphon the water out of the intermediate traps in passing, or the trap itself which is used. The vents for this purpose should be at least two inches in diameter, and may all branch into each other and into the soil-pipe above the upper closet, as shown in the annexed diagram, Fig. 9. Thus, if we suppose a pailful of water to be emptied into the slop-sink on the upper floor at A, its rapid fall through the vertical soil-pipe would be likely to take with it by friction the air in the branches draining the closets at B, C, D and E. The traps of these closets would be likely to be drained by this siphon action, as above described, or by their own use, unless provided with vent-pipes, as shown in the figure. A closet placed as at F, connecting with the main soil-pipe where the latter is not vertical, is not subject to such action from use of those above, and has been found by actual experiment to be unaffected by their use when the main soil-pipe has an open top, as here shown. It would therefore probably not be necessary to apply a special vent-tube to its trap unless the vertical pipe immediately below it is several feet in length. If such be the case, the discharge of this closet itself might siphon the water out of the trap behind it, unless such a vent be provided, so that it is hardly safe to omit the vent in any case.

For those places where the cost of a Jennings water-closet is felt to be a burden, a simple hopper-closet is the best substitute. But it should be properly ventilated under the seat, and its trap ventilated, and good provision made for flushing. This closet is described in Fig. 8 (p. 454), and consists of a hopper or bowl of crockery, set over a lead trap, or, what is better, a bowl with crockery trap in one piece. This closet gets rid of the confined chamber of foul air which condemns the pan-closet, and this is also easily cleaned, and simple. Its only fault is that the contents of the trap are directly exposed, so that trouble would ensue if ample flushing were not provided. It is sometimes provided with a constant flow of a driblet of water, which is both wasteful and inefficient. The flushing-water is needed only at the time of using the closet, or rather when leaving it, and it should then be applied in a sufficient quantity to drive the contents of the

Simpler
water-
closets.

trap entirely through into the drain below. If a tank or service-box be applied to flush it, a definite supply of water can always be insured without such a waste as would render its use objectionable. In the way it is now used, the large amount of water wasted has led to the imposition of a special tax upon hopper-closets by the Boston Water Board. This waste, however, is an abuse, and not a necessary contingent upon the hopper-closet. The aperture at the bottom should be limited to about three inches in diameter, to prevent the admission of substances which might choke the drain.*

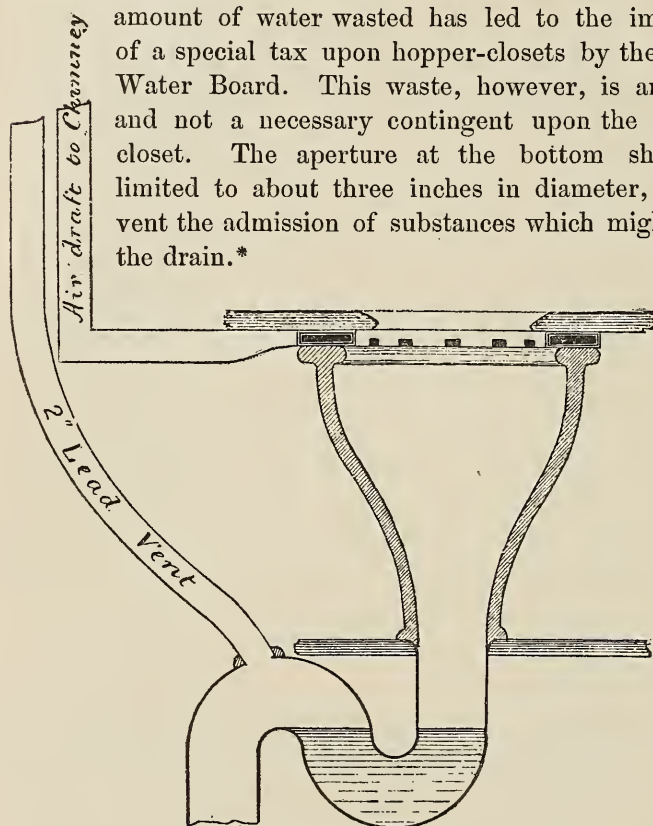


FIG. 8.—Hopper-Closet.

Direct supply of water-closets.

It has been usual with many plumbers of late to recommend the flushing of water-closets of the common "pan" or "hopper" style by a valve to be opened in a branch of

* In order to insure a sudden delivery of water to expel the foul contents from the trap of a hopper-closet, the service-box should have a capacity of at least a gallon, with a funnel-shaped bottom. The valve should be not less than two inches or two and a half inches in diameter, and the pipe leading the flushing-water to the hopper should be two to two and a half inches diameter, according to its length. Without such special provision for the sudden dash of water in a considerable volume, the exposure of foul matter in the trap would be sure to give trouble, as is the fact in all those in common use.

the main water-supply of the house, from which drinking-water is drawn through another faucet. But the only safe way is to break this connection by providing a small tank and service-box for the closet. With the valve furnishing water direct from the main, the following risk is incurred: The water-supply, even though nominally "constant," is sometimes shut off temporarily for repairs in the street, and if at such time the water-closet valve should be opened, the air is drawn rapidly into the water-pipes from the interior of the closet, which is filled with organic vapors, and perhaps with actual contagium from disease. The water is soon let into the pipes again, mixing with this air and dissolving a portion, thereby becoming contaminated and unfit for drinking. This direct connection-valve has become so popular that one of the prominent dealers in plumbers' supplies recently alluded to the service-box supply as an "old-fashioned way which was going out of use," while conversing with the writer. In the supplementary report of the medical officer of the Privy Council for 1874, there is an interesting report from Dr. Buchanan, upon an outbreak of enteric fever in Caius College, Cambridge, where fifteen students were attacked while living in a building which was supposed to be provided with the most perfectly arranged sanitary appliances. After a most painstaking investigation, the fever was traced, by convincing evidence, to the use of a water-closet with direct supply from the mains, which had poisoned the water used for drinking in precisely the manner indicated above. In the same report, the following extract is found from the regulations under the metropolis water act of 1871: "These regulations having for their object the preventing of undue consumption or contamination of water, are the result of an inquiry made for the Board of Trade by Lord Methuen, Captain Tyler, and Mr. Rawlinson, C. B. They have the sanction of the Board of Trade, and may be put in force by the London water companies." "Every boiler, urinal and water-closet in which water supplied by the company is used (other than water-closets in which hand-flushing is employed) *shall*, within three months after these regulations come into operation, *be served only through a cistern or service-box*, and without a stool-cock, and *there shall be no*

Fever at
Caius Col-
lege, Cam-
bridge.

London reg-
ulations for
indirect sup-
ply to water-
closets.

direct communication from the pipes of the company to any boiler, urinal or water-closet." "No pipe by which water is supplied by the company to any water-closet shall communicate with any part of such water-closet, or with any apparatus connected therewith, except the service-cistern thereof."

PUBLIC PRIVIES.

Public privies needed.

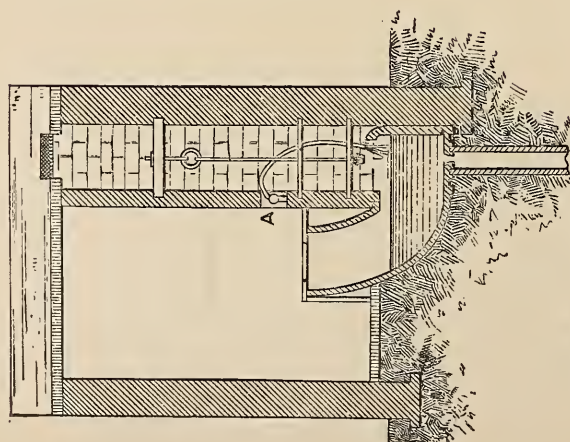
The need of a system of public privies for the crowded parts of large towns is a subject inviting the earnest attention of all who are interested in sanitary reform. All decent people who have occasion to frequent the narrow and crowded alleys where the poorer part of the people are lodged, will often be reminded of the streets of Rome and other European cities by the want of decency there prevailing. Among the various appliances used in different towns for this purpose, all have failed, unless where kept under the supervision of the local authorities. One thing is certain: the removal of filth is imperative, and it cannot be left for the people who use such public privies to take care of the apparatus. Under the same class may be considered the privies of jails, asylums, and other public institutions where large numbers are housed whose habits of cleanliness cannot be relied upon. For this purpose the water-carriage system is quite as applicable as in private houses, if only suitable apparatus be provided, and if it be supervised by local authorities. Such apparatus has already been perfected in Liverpool, and in Bristol, England. Similar apparatus has lately been introduced in the schools at Dantzic, where the climate is about as rigorous as in Massachusetts. Annexed to the report of the medical officer of the Privy Council for 1874 is an interesting report by Mr. J. Netten Radcliffe on the means used in various towns for removal of excrement. Among his "conclusions" is the following (p. 154): "As regards the parts of a town or village inhabited by the poorer classes, a water-closet system may be managed so as to be entirely applicable to the circumstances of the most ignorant and most careless population. Essential conditions of such applicability, however, are, that the structural arrangements should be adapted to their purpose, and that the management should be wholly undertaken and efficiently done by the servants of the sanitary authority.

Liverpool trough-closets.

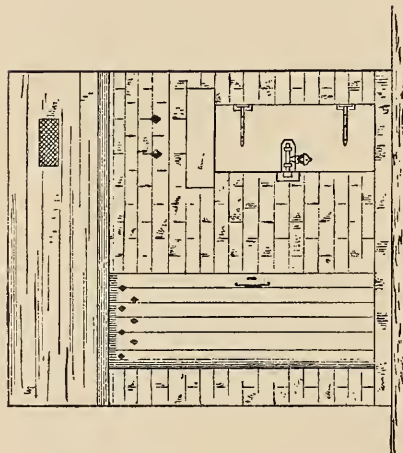


LIVERPOOL CORPORATION. TROUGH WATER CLOSET.

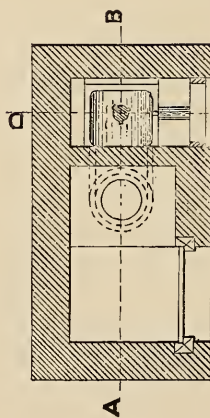
FIG. 10.



SECTION THRO' A.B.

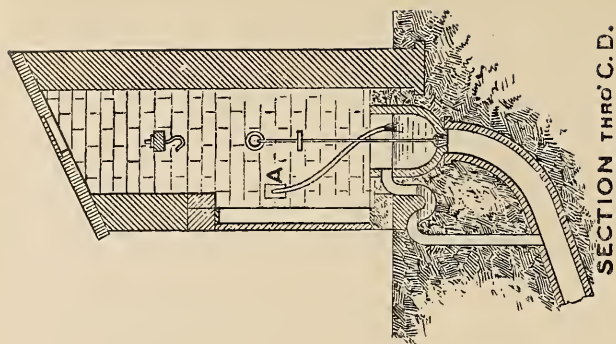
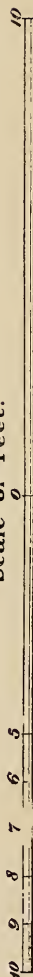


ELEVATION



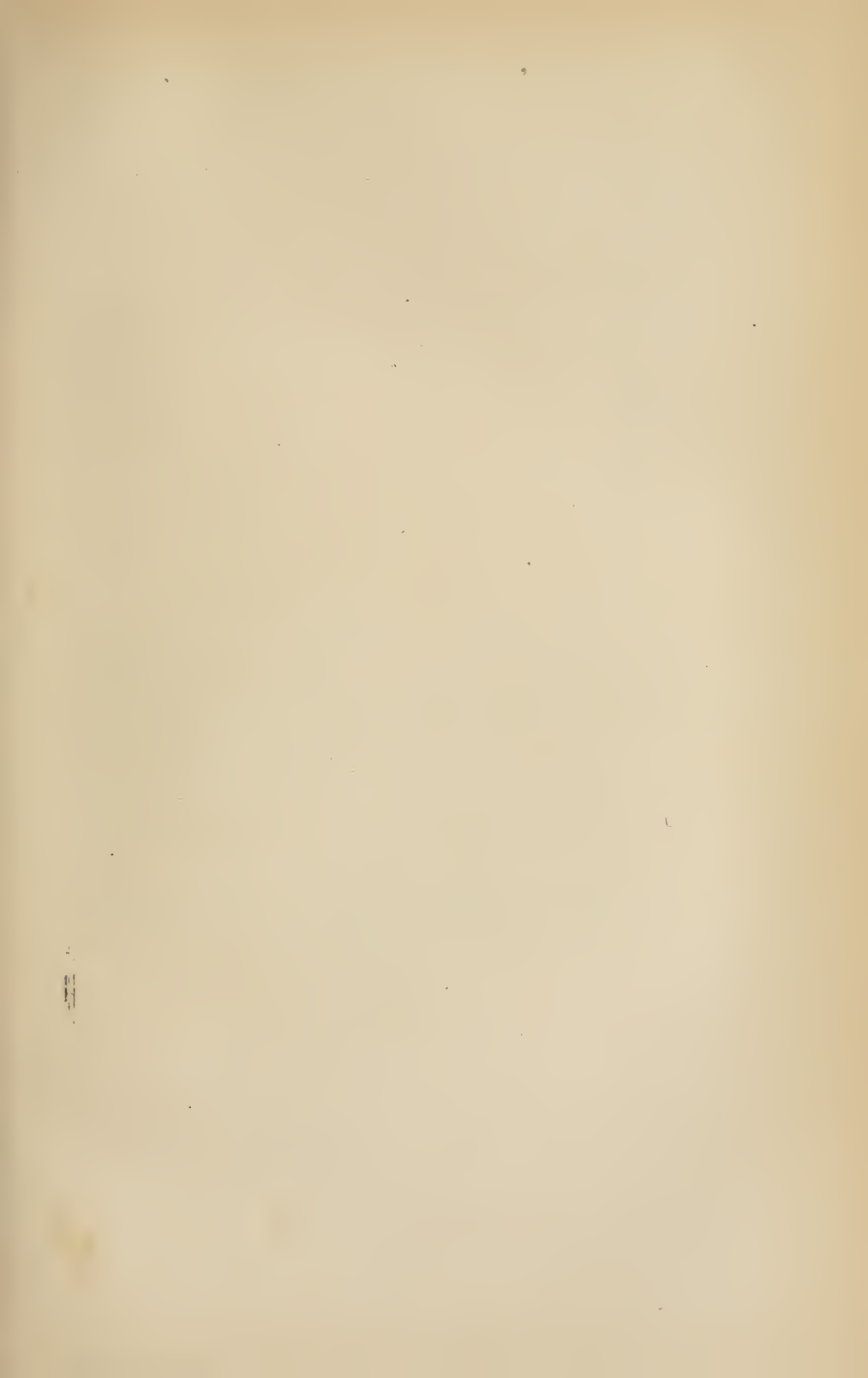
PLAN

Scale of Feet.

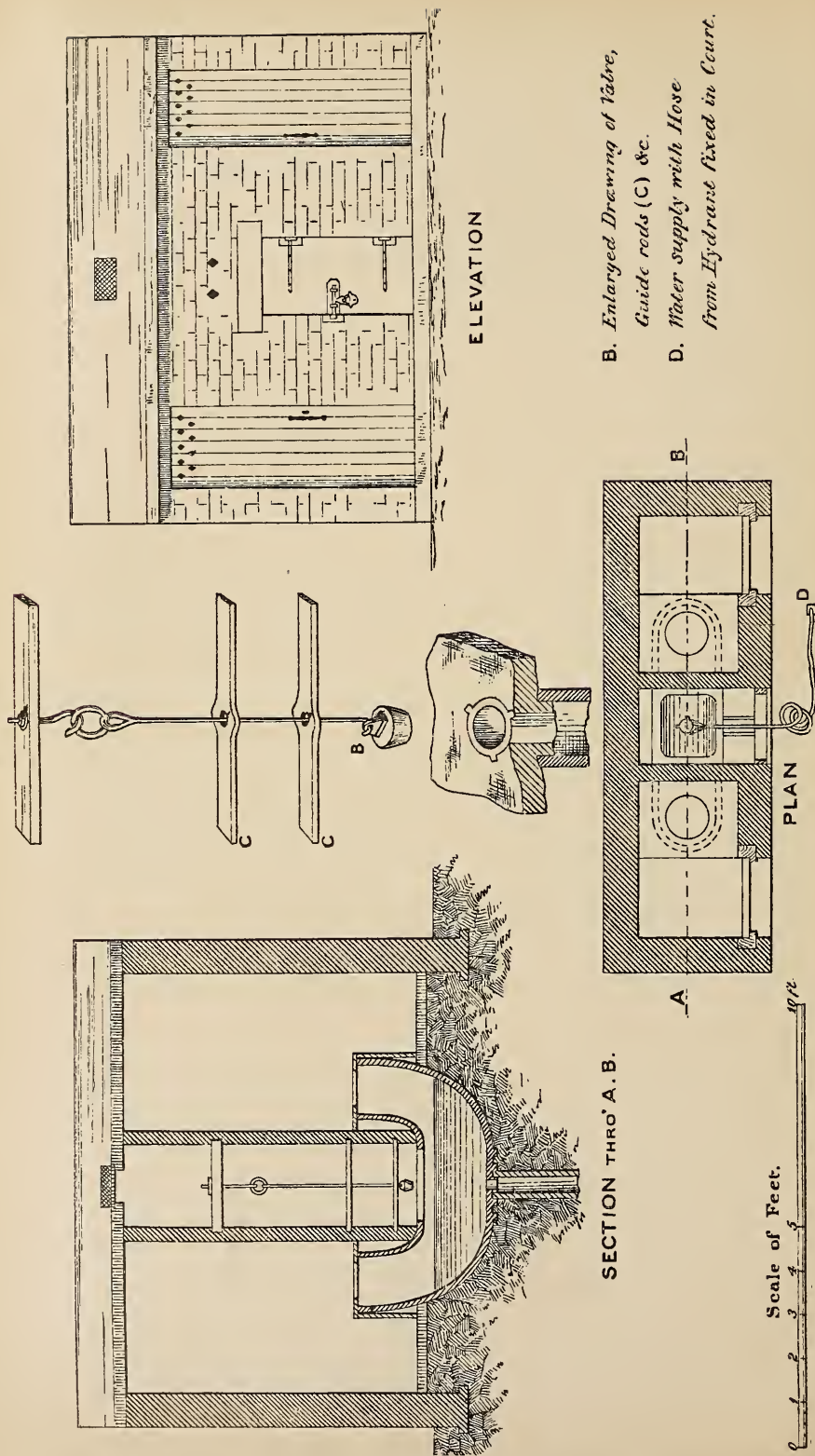


SECTION THRO' C.D.

*A. Water Supply from Hydrant
with Hose inside Chamber.*



LIVERPOOL CORPORATION. DOUBLE TROUGH WATER CLOSET.
FIG. 11.



SECTION THRO' A. B.

- B. Enlarged Drawing of Valve,
Guide rods (C) &c.
D. Water supply with Hose
from Hydrant fixed in Court.

Where these conditions are observed as thoroughly as they are observed in parts of Liverpool and Bristol, water-closets are the best means of removing excremental matters from the poor neighborhoods of a town." In speaking of the introduction of these improvements in Liverpool, the same report says (p. 206) : "The council, in order to secure uniformity of action, and likewise to prevent future mistakes in the application of remedial measures, directed the town clerk to notify the several owners against whom proceedings should be taken, 'that it appears to the said council of the said borough, that the only effectual remedy for such privies and cess-pools is by converting the same into water-closets.'"

"Since Dr. French has been medical officer, and mostly since 1866, he has ordered and obtained the conversion of 14,393 privies into water-closets ; and there were in 1869, in Liverpool, 20,000 privies attached to ash-pits and 31,150 water-closets, 2,150 of which are tank or trough closets." "These closets are constructed on a pattern ordered by the corporation, and approved, as to details, by the borough surveyor. Now, in 1874, the number of troughs for trough-closets is 3,304, serving for about 6,000 closets, and the number of water-closets other than trough-closets, 43,395." In order to explain more definitely the nature of the trough-closet, the annexed plates are copied from the same report of Mr. Radcliffe (figs. 10 and 11), with the following remarks (p. 206), viz. : "There is peculiar interest in the arrangement and working of the trough-closets which are in use by numerous families in the sort of neighborhoods where in other towns ordinary water-closets are commonly a failure and a nuisance. It remains to say that the position chosen for these new closets has been carefully determined by the circumstances of each place where they have been erected, and that peculiar facilities for their being well placed have been obtained by the time of their erection concurring with that of other improvements. The closets that are common to several families are cleansed in rotation by the people using them, and a register is kept of the order in which this should be done. Inspectors visiting the closets every two or three days see that this duty is performed, and are themselves held responsible for any shortcoming. By a little patience and firmness the inspector

succeeds in obtaining the necessary cleansing even among the most intractable classes; with very little assistance from the law. He will, if necessary, wait and see the closet cleaned out by the proper person. Last year only a dozen or so of people were summoned for neglect in this respect, and three of the offenders had to be sent to prison. It will be seen from the drawing that in connection with these closets there is an opening of access to the trough and water supply. This opening is for the scavenger, and the people using the closets have no concern with it. The scavengers are employed by the corporation, and every day they visit each of the trough-closets, unlock the iron door of access, discharge the contents of the trough, flush it out with hose and water, sweep it thoroughly clean, and leave it charged with fresh water for the next twenty-four hours' use. Frost has done no harm to these trough-closets, nor yet to the ordinary siphon-closet with its service-box." "There can be no question of the admirable efficiency of the working of the arrangements above described in the semi-public privies, nor of the recognition by the people of the superiority of the new to the old arrangements. Nor can there be any question that these results are due even more to the management of the whole business by the public authority than to the excellence of the constructive arrangements themselves. And not only is complete freedom from nuisance obtained where formerly filth and stink were universal, but Dr. French states that in 1868, when an epidemic of enteric fever was prevailing in and about Liverpool, 'the only localities that seemed exempt from it were the places occupied by the poor, in which we had removed all the privies and made trough water-closets.'"

Traps.

The use of traps on every waste-pipe inside of a house is a point upon which some difference of opinion is found. If the outside trap upon the main drain is well constructed and ventilated, there is somewhat less importance to be attached to those on each separate waste-pipe. Dr. O. Reynolds, in his little work entitled "Sewer-Gas, and How to Keep it out of Houses," thinks they may in most cases be safely dispensed with. But every waste-pipe becomes lined with a slimy film which, in a climate subject to such summer heats as ours, must needs decompose and give off offensive effluvia. The

difference of temperature in different parts of a house, and the winds outside, would always keep up drafts through waste-pipes if not trapped, passing down one orifice and up another, so that a dwelling-house can hardly be considered safe with us unless traps are provided at every waste somewhere within ten feet of its orifice. The chief objection to traps, except their cost, is that they delay or hinder, to a certain extent, the rapid efflux of the sewage, and keep a small quantity of it shut up to decompose within themselves. Moreover, there is always a column of confined air in a waste-pipe between any two traps in the same line of drainage. Care must therefore be taken to give this column a free connection or vent to the atmosphere, so that its tension may always be in equilibrium with the atmospheric pressure. Without this system of vents the traps are worse than useless, and deserve their name from the disappointment that would be sure to follow their use.

Traps should be used at every waste inside a house.

The best form of trap is that which gives least obstruction to the flow of the sewage, and requires the least quantity of water to insure its seal. All square corners tend to promote an accumulation of sediment or slime, which should be avoided. No form of trap is so simple and so generally efficient as the ordinary S-bend. Its calibre should be about as large as that of the pipe of which it forms a part, with continuous, smooth lines. When a waste-pipe is expected to carry at times a full stream of water, as from slop-sinks, wash-trays, and bowls, there is risk of having the traps siphoned by the last water passing down, unless they be provided with a vent-hole at the top, and this must of course have a pipe to carry its effluvia to the top of the roof.

Form of traps.

The position of traps is a matter of some importance. If close to the orifice, as in the common sink bell-trap, a slight obstruction of sediment will soon serve as a nucleus for a complete dam; but if two or three feet below the orifice, and directly under it, such a slight obstruction would soon be swept away by accumulation of the two or three feet head of water above. The common bell-trap used in sinks, and attached to the strainer, conforms to neither of the above conditions, and is a mere subterfuge. Being close under the strainer, no head of water can accumulate to flush it, and its

Position of traps.

Bell-traps of no use.

large annular depression is a receptacle of rubbish, In fact, it is a mere obstacle to the drainage, so that most cooks lift the cover when they want the water to run off, losing the benefit of both strainer and trap together. A strainer is useful, if screwed fast down, with holes of ample size and number, and a trap made of the S form about the level of the floor, under a wash-tray or sink, will run for years and keep itself clear of sediment, with such a strainer over it.

WORKMANSHIP.

Workman-
ship.

This subject has been mentioned above, but its importance may justify something further. There is generally but one way in which to do a thing properly and well, while there is an endless number of wrong ways into which workmen stumble, through ignorance or recklessness. The importance of having the best quality of work in matters that so nearly affect the health and lives of our families, need not further be dwelt upon. These two facts confront us. Good work is the Alpha and the Omega of good drainage, and good work is too rare an article among the workmen in mechanical trades. Two hundred years ago, the artisans' guilds of the north of Europe developed a degree of skill which often made an artist of the artisan, producing such men as Albrecht Dürer and Peter Fischer, of Nürnberg, while the general emulation led to a degree of excellence in workmanship among large numbers that calls for our admiration, and gave a tone to the civilization of that age well worthy of imitation. Our modern "trades unions," however, seem to have encouraged a lack of thoroughness and lack of interest in the artisan by making too little distinction between the faithful and the unfaithful workman. They combine for mutual protection against evils which they themselves tend to aggravate, and are led by demagogues to fix arbitrary rates of wages, regardless of merit, and encourage no emulation for excellence. The consequences are bad enough, morally, in the lowering of the standard of excellence among artisans, and thereby degrading their intellects, as well as their morals; but the results are particularly disastrous among those who employ artisans to construct such important works as house-drains, for the average householder necessarily depends largely upon the intelli-

Too little
emulation
for excel-
lence.

gence and skill of the artisan for the perfection of details in such work, concerning which he, the employer, is ignorant. Of course the blundering and reckless apprentice becomes, in time, the ignorant and stupid master-workman, deficient in skill, and confined to routine.

Instances often come to our notice like the following: Cases of unfaithful work.
Some years since the writer employed a man sent from one of the best plumbing establishments in Boston to attach a vent-pipe to a soil-pipe in an old house, which had been built, like thousands of others, without one. The workman was directed to lead the vent into the kitchen chimney-flue, which was conveniently near. This pipe was afterwards seen, entering the side of the chimney-breast, and appeared all right. A few weeks since, a new tenant in the house complained of a bad smell. After searching all about for its source, suspicion led to an examination of the connection of this vent with the chimney. It was found that it *never entered the chimney at all*, but ended with an open mouth in the furring-space between the chimney and plastering! Of course all the gases passing out of this vent, had for years had free access to all the floors of the house. Luckily nobody had had typhoid fever; but no thanks are due to the plumbing for the immunity.

Another instance of bad faith in a laborer occurred within a few months in the same street. A recent introduction of aqueduct-water led to laying a service-pipe into a house where it happened to cross under the drain in the front yard. The foreman was cautioned about the drain, which was of Scotch pipe. Some months afterward the occupants of the house found filth oozing through the front cellar wall of the house in midwinter. On digging down through four feet of frozen ground in the front yard, the Scotch drain-pipe was found to have been broken open and placed together again without using any cement, while putting the water-pipe through under it. No mention being made of this fact, it was not suspected till the leakage made its way through the cellar-wall, as above related. Men who are guilty of such acts of bad faith are not likely to be employed further by the same parties; but some more serious penalty than loss of patronage seems to be needed for such cases, where the

results may be the illness and death of their fellow-citizens and neighbors.

Duties of
architects.

The want of skill among artisans has been aggravated by a degree of ignorance on the part of architects upon points where they are expected by the community to be experts. It may be urged in their defence that house-drainage is a comparatively new luxury. If so, the architects should be the very class who, from their position, should do the most towards developing its perfection, and not leave it, as is often done, for the confused notions of their clients to work out the details, with the advice of the head mason, neither of whom have probably ever studied the subject from any point of view more comprehensive than from their own limited experience. Much has been written on these subjects; so much, that but few new ideas have been brought forward in this paper. Those who wish to study it further will find it more amply treated by such men as Bazalgette, Latham, Corfield, Eassie, Menzies, Parkes, Reynolds, Waring, Shedd, and others, all in our own language, besides as many more in German and French, wherein the peculiar stand-points of the various writers give rise to different treatment, each suited to its own locality or climate. Besides the study of the experience of others, much remains to be done to adapt means to ends, taking into account the peculiar circumstances governing each case under treatment. What the community has a right to expect, is, that men having in hand the designing and erection of their dwellings, should inform themselves of the conditions on which such dwellings can be made healthy places of abode. If they did this, as a rule, and if artisans had, as a rule, that pride of character and love of good workmanship which is the capital of the mechanic, we should soon see better results.

The writer does not intend to ignore the fact that there are many intelligent and painstaking architects, who have given this subject careful attention; but for some reason or other, there are many of our important buildings designed and erected under the charge of those who are not so distinguished. The following examples came under the writer's notice, within a short time, which may serve to illustrate this point.

A conspicuous public building, costing nearly \$200,000, was lately erected under the charge of a leading architect. Like most similar buildings of the present day, it contains a good deal of plumbing. For some time past a nauseous odor pervaded the cellar, which no amount of window opening would remedy. It increased to such an extent as to fill the whole building, and render its occupation sickening. On inquiry, it was found that some square cesspools had been constructed under the cellar floor, into which various drain-pipes entered, and from which a brick drain led, covered with flat stones, an invention of a past age. One of these reservoirs of filth under the cellar floor had been forced to overflow, and had saturated the concrete pavement, after a temporary obstruction of the outlét by a careless workman. Although the obstruction was promptly removed, the stench remained a long time. What good purpose the cesspool served, or is capable of serving, is past comprehension. Its presence is a mere nuisance. The brick drain could hardly have been planned by a person who had taken pains to learn the inherent faults of such structures, and the great superiority of smooth pipes. Mistakes
in planning.

Another case : a large public building was recently planned by an architect, chosen by the parties who had the subject in charge, as peculiarly versed in the wants of such an institution as this was to accommodate. The plans showed a brick drain, big enough to crawl through, running under the building for a length of over two hundred feet, too large to be self-cleansing, and, therefore, merely a prolonged cesspool, over which a population of about five hundred persons were to be lodged, those living on the lower story being on a stone floor, resting on the ground, without a cellar or any subsoil drainage, except the brick sewer ! This was not all. A large tank or cesspool was provided, just outside the building, in which the whole sewage of this population was delayed, to settle and ferment till convenient times for its removal, although a good sewer was at hand for its immediate and rapid transit to a safe distance.

DUTIES OF PROPRIETORS AND OCCUPANTS.

Duties of
proprietors.Care re-
quired.Dangers
from frost.Record of
drains
needed.

However well a system of house-drainage may be planned and constructed, it cannot be expected to be entirely automatic, or to serve its owner for an unlimited period without intelligent supervision. In fact, "eternal vigilance" is the price of safety in such matters in a climate where such violent and sudden changes occur as in ours. Sometimes a trap may freeze in January and dry up in July. Deep frosts sometimes break up drains, and leave them leaky. Rats burrow into and gnaw into drains, if not thoroughly built. The gases given off by sewage often corrode lead pipes, and the ammonia in water-closets corrodes the copper pans. Valves become leaky by wear. Counterpoises get loose. But frost is our greatest enemy; a frozen water-pipe often does much damage, but a frozen drain is the climax of discomfort. With the extended use of plumbing come the increased risks of such mishaps, till many householders long to simplify the apparatus. It cannot certainly be well taken care of in country houses in our climate, unless the occupant knows where to find the pipes, and how to empty them on frosty nights. The risks of leakage of drains are of course very serious, and the difficulty of tracing such troubles to their sources renders it imperative to keep a careful record of their position, and to take the alarm from the only sense by which we can often be led to detect them, acting vigorously to repair the defect when found. Those who do not wish to trouble themselves with such matters had better dispense with drains entirely, and do as in the days of our fathers; viz., carry the refuse-water to a safe distance from the house in pails, where it can be consigned to mother earth. Then they can feel sure that it is beyond the chance of harming them in the house.

REPORT

ON AN

OUTBREAK OF INTESTINAL DISORDER, ATTRIBUTABLE
TO THE CONTAMINATION OF DRINKING-WATER
BY MEANS OF IMPURE ICE.

By A. H. NICHOLS, M. D.,
OF BOSTON.

REPORT ON AN OUTBREAK OF INTESTINAL DISORDER, ATTRIBUTABLE TO THE CONTAMINATION OF DRINKING-WATER
BY MEANS OF IMPURE ICE.

Rye Beach is an attractive and popular seaside resort upon the coast of New Hampshire, about fifteen miles distant from the north-eastern corner of Massachusetts; during the months of July and August of each year it is thronged with visitors from the large cities.

At the beginning of the season of 1875, there broke out among the guests of one of the large hotels of this place, a somewhat extensive, though comparatively mild epidemic. Being the only practising physician in the vicinity, I was requested by the proprietors of the hotel to make a detailed investigation as to the causes of the disorder. The results of this examination revealed a novel and commonly unsuspected source of contamination of drinking-water, and they have, therefore, seemed to me worth communicating to the Board of Health. The disorder in question may be comprehended under the general term disturbance of the digestive system, characterized by a sensation of giddiness and nausea, vomiting, diarrhoea, severe abdominal pain, all of which was accompanied by fever, loss of appetite, continued indigestion, and mental depression. The epidemic, although confined within very limited boundaries, baffled for a considerable time all efforts to trace the trouble to any specific cause; while the *origo mali*, when ultimately detected, proved to be contained in an article of ordinary consumption, usually considered as above suspicion as regards innocuousness. The first few cases coming under observation did not attract particular attention, inasmuch as the symptoms manifested did not differ essentially from those noticed among the visitors in previous years, and

induced by drinking the well-water of the place, which, especially when the wells are low, is strongly impregnated with sulphate of lime, carbonate of lime, and magnesia. It very soon became apparent, however, that the trouble was limited to the inmates of a single hotel, accommodating about 300 guests, whereas the occupants of another public house, containing rooms for about 200, and distant but one-eighth of a mile, were enjoying an absolute immunity from all illness; nor was any similar trouble known among the neighboring cottages, containing at least 500 visitors.

This peculiar grouping of the patients rendered it, therefore, tolerably certain that the whole disorder must be referred to some specific, local origin, to be sought for in the immediate vicinity of the hotel; and popular opinion pointed very strongly, from the outset, to the drinking-water. This was drawn from several wells, all sunk in an elevated ridge, and safely removed from drains, cesspools, dung-heaps, or other source of pollution. It was also ascertained, upon inquiry, that, in some instances, those persons affected, having apprehended trouble from the use of the water, had carefully limited themselves since their arrival to other beverages, but, as afterwards transpired, had not hesitated to use ice, either melted or otherwise.

With respect to the drainage of the house, it appeared that during the previous winter the services of competent engineers from Boston had been secured, under whose supervision an elaborate and complete system of sewerage had been recently constructed, by means of which all the discharge from the various sinks and water-closets was conveyed directly into the ocean. The point of discharge of this sewer was at a safe distance from the house, while the sewer itself was securely trapped and ventilated in such a manner as to preclude the idea of the escape of any foul gas within the house.

Attention was next directed toward the cooking utensils, but all the articles pertaining to the kitchen were found to be scrupulously clean, nor did it appear that any agent or utensil was employed in the preparation of the food which would in any way tend to produce the symptoms complained of. Furthermore, the milk-supply was investigated, and found to be of unquestionable purity.

The process of elimination was in this manner continued, until at length suspicion became directed to the supply of ice furnished to the house. It may be mentioned at this point, that a large portion of the ice consumed in this town is gathered from shallow ponds, formed during the winter by the flooding of meadows, and, therefore, contains as a rule, more or less grass and other vegetable matter, and is consequently far less transparent than the article commonly supplied in our large cities. I was not particularly surprised, then, to find that the ice in this case was rather impure and opaque, and that it contained numerous foreign substances varying in size, and apparently of vegetable origin.

The theory that the outbreak, now increasing in extent and severity, was dependent upon the ice-supply, was suddenly strengthened by some pretty direct evidence, of which the following examples may be given:—

1. A resident of the place, upon being questioned upon the subject, volunteered the testimony that during the previous winter he had taken home some ice from the same pond where the ice-supply of the hotel was obtained, and having consumed a portion with the view of testing it, had experienced nausea and distress for the remainder of the day, which led him to decide that it was unfit for use.

2. Several persons affirmed that they detected a decidedly disagreeable odor emanating from the ice as it melted.

3. Two gentlemen having taken a quantity of ice with them upon an excursion, and drunk the water formed from it, were made violently ill.

4. The atmosphere of the house in which the suspected ice was stored was found to be decidedly offensive.

5. When some of the melted ice-water was poured into a glass, and held in front of a dark-colored object, a strong light striking the glass from one side, it was found to be decidedly discolored, and charged with suspended matter.

A visit was now made to the pond, and the condition of things here found removed all doubt as to the exceptional foulness of the water from which the ice was formed.

This pond is a flooded marsh, of irregular outlines, about two-thirds of a mile in length, and varying in width from 200 to 800 feet, with a uniform depth of about two feet. The

source of the water-supply was a small brook entering the lower end of the pond (bringing down all the sawdust from two neighboring saw-mills), and several springs said to be situated at the upper end. There had formerly existed an artificial channel, by means of which was maintained a direct communication between the pond and the ocean; but for the past two years this channel had been filled up with sand and stones thrown up during heavy storms by the action of the sea, which drives in here with extreme violence. Of late, therefore, the water of the pond has become practically stagnant, although a small quantity constantly percolates a bank of gravel separating the pond from the ocean.

A glance at the lower end of the pond was sufficient to demonstrate the source of the foulness of the water, for at this point, a space of about 500 long and 150 feet wide, directly in front of the mouth of the brook, was occupied by a homogeneous mass of putrescent matter, composed of *marsh mud* and *decomposing sawdust*. The water in the vicinity of this bank was discolored black, and when stirred up emitted an intolerably offensive odor. Several large houses are situated at no great distance from this end of the pond, the occupants of which, upon being questioned, asserted that when the water was stirred up by the rowing of boats, or ruffled by a wind blowing in the direction of the houses, the air was not unfrequently polluted to such an extent as to render it necessary to close the windows. Of course there could be no question but that this foul matter held in suspension in the water was conveyed by currents and winds to every part of the pond, and in sufficient quantity to render the water in every part absolutely unfit for drinking purposes.

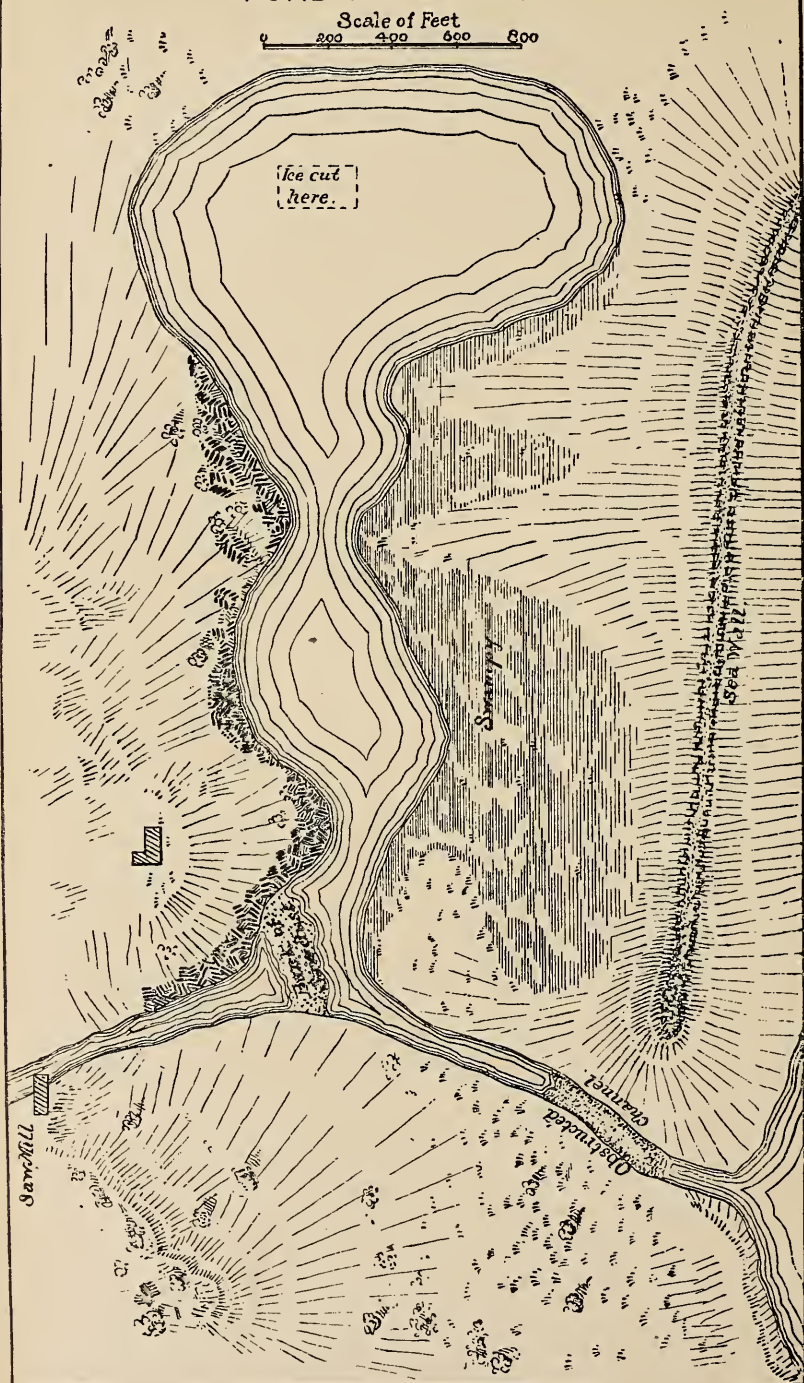
In order to obtain further evidence as to the admixture of this foul matter with the ice, a quantity of the ice having been cleansed from all surface impurities was placed in a tub to melt, and the water thus obtained was poured into a fresh demijohn, sealed and forwarded for analysis to Prof. W. R. Nichols, who reported as follows:—

“The water contains in suspension a considerable quantity of vegetable matter more or less decayed, and possesses a slightly disagreeable odor, which becomes more evident if the water is warmed.

POND at RYE BEACH

Scale of Feet

0 200 400 600 800



“Of the organic matter which is suspended in the water, and which may be removed by filtration, a portion, consisting of the larger and heavier particles, settles somewhat readily. Another portion, being more finely divided, remains for an indefinite time diffused through the water, and would be drunk by any one using the ice in the ordinary way.

“I do not think it unreasonable to suppose that the presence of this decaying organic matter may have been instrumental in bringing about the unpleasant results you have observed.”

A sample of water was likewise taken for examination from the pond in question. This sample was obtained from the central portion of the pond, in the early morning, when no air was stirring, and the water being quite calm and undisturbed by undercurrents, the greater portion of any matter held in suspension would at that time be precipitated to the bottom of the pond. Consequently, the sample taken would represent the purest water obtainable from the pond under any circumstances.

The numerical results of these analyses are herewith appended. For the purpose of affording a means of comparison, there are also presented the results of analyses of a sample of ice supplied by the Boston Ice Company, and of the Cochituate water.

The subjoined sketch of the pond (drawn by Edward K. Clark, C. E.,) will serve to convey an idea of the general outline and character of the pond, the location and relative extent of the bank of sawdust and marsh mud by which the water was fouled, and the portion of the pond from which the ice was taken.

The proprietors of the hotel, impelled by a proper sense of the responsibility resting upon them, rendered willing assistance in ferreting out the source of the trouble, and as soon as suspicion was directed towards the ice, its further use was promptly prohibited. Coincident with this disuse of the ice, there was observed an abrupt amelioration in the symptoms of nearly all who had hitherto been ill, while during the remainder of the season, no fresh cases of this character are known to have occurred.

The evidence thus collected seems to render it almost

certain, that the illness in question was induced by the consumption of ice contaminated by decomposed organic matter.

As to the actual, or relative, number of those made ill in this manner, no exact estimate can be made, for the symptoms were, as a rule, not sufficiently severe to necessitate the aid of a physician.

As an approximate estimate of the extent of the mischief produced, it may be said in round numbers, that the ice was consumed in variable quantities during a period of six weeks by five hundred individuals. Of these, twenty-six adults were known to manifest grave, continued, and characteristic symptoms. A large number, probably the majority, of the guests drank the contaminated water with apparent impunity. In some, although decided illness was induced during the first two or three days after their arrival, an habituation to the water seemed to be afterwards acquired, and they enjoyed a subsequent immunity from all trouble. In the case of several, on the other hand, the stomach seemed to resent with ever-increasing emphasis the presence of the foul water, nor was relief obtained until after the patients had quit the place. Thus many who had come from a long distance with the hope of strengthening and improving their physical condition, returned home depressed, and without even having preserved the health they previously had.

It is worthy of remark, that no person under the age of ten was known to be affected by the impure ice.

Great responsibility devolves upon those who undertake to provide food and drink for large numbers of individuals, and to such the above experience inculcates the importance of giving especial attention to the purity of the drinking-water, and guarding against every possible source of contamination.

The notion that ice purifies itself by the process of freezing, is not based upon trustworthy scientific observation. On the contrary, it is utterly wrong in principle to take ice for consumption from any pond the water of which is so fouled as to be unfit for drinking purposes.

Numerical Results of Analyses.

COMPONENT PARTS.	ICE TAKEN FROM CONTAMINATED POND AT RYE BEACH.*				ICE SUPPLIED BY BOSTON ICE COMPANY.†	
	Results expressed in parts per 100,000.		Results expressed in grains to U. S. gallon.		Results expressed in parts per 100,000.	Results expressed in grains to U. S. gallon.
	Unfiltered.	Filtered.	Unfiltered.	Filtered.	Unfiltered.	Filtered.
Ammonia, ...	0.0208	0.0213	0.0121	0.0124	0.0045	0.0026
Albuminoid ammonia, ...	0.0704	0.0165	0.0410	0.0096	—	—
Inorganic matter, ...	7.80	6.88	4.55	4.01	0.45	0.26
Organic and volatile matter, ...	5.72	2.84	3.33	1.66	0.31	0.18
Total solid residue at 212 deg. Fahrenheit, ...	13.52	9.72	7.88	5.67	0.76	0.44
Chlorine, ...	—	3.23	—	1.88	Trace, less than 0.02	Less than 0.012
Oxygen required to oxidize organic matter, ‡.	—	0.334	—	0.495	0.033	0.019

* Small amount of nitrates.

† Trifling amount of suspended matter.

‡ Determined by permanganate of potash.

Numerical Results of Analyses—Continued.

COMPONENT PARTS.	WATER TAKEN FROM POND AT Rye Beach.*		Cochituate Water. Mean of a number of determinations. Results expressed in grains to U. S. gallon.
	Results expres'd in parts per 100,000.	Results expres'd in grains to U. S. gallon.	
Ammonia, ...	0.0197	0.0115	0.0020
Albuminoid ammonia, . .	0.0597	0.0348	0.0068
Inorganic matter, ...	64.96	37.88	1.61
Organic and volatile matter, .	8.00	4.66	1.22
Total solid residue at 212 deg. Fahrenheit, ...	72.96	42.54	2.83
Chlorine, ...	34.00	19.83	0.18
Equivalent to chloride of sodium, ...	56.03	32.68	—
Oxygen required to oxidize organic matter, ...	1.28	0.75	—

* Residue blackens strongly when heated. Evidently a large amount of organic matter.

REPORT
ON THE
REGISTRATION OF PREVALENT DISEASES.

By F. W. DRAPER, M. D.,
OF BOSTON.

REPORT ON REGISTRATION OF PREVALENT DISEASES.

The desirability of a trustworthy method for the registration of prevalent diseases is undisputed. Sanitarians have repeatedly expressed the want, but have failed hitherto to realize its fulfilment. They know how much greater would be their power to protect the public health, if data of the local development and progress of disease were promptly afforded to them. They recognize the fact that the utility of such a registration is amply illustrated in the control which boards of health exercise during invasions of small-pox prompt measures of prevention by isolation being thereby made possible for the defence of the entire community. In a still broader sense, they see the great advantage which would result from the opportunity to study the rise and fall of epidemics, and the development of diseases whose cause lies in local and preventable conditions.

Hitherto health authorities have relied on the registration of deaths as affording a basis for their active operations in behalf of the public welfare, as well as for generalizations in sanitary science. A persistently high rate of mortality is an indication that something is wrong in the sanitary condition of the community reporting it; it is a signal that so far as that region is concerned, influences are at work which demand speedy investigation and, if it be possible, prompt removal. Therefore the registration of mortality has always been acknowledged as an invaluable adjuvant to sanitary administration.

But it is obvious that the death-rate does not represent the actual state of the public health, the real amount of sickness, or its real character at any given time in any community.

An entire hamlet may be smitten by an epidemic which makes no impression on the bills of mortality. The schools of a township may be forced to take an unseasonable vacation by a general invasion of whooping-cough, which may cause a comparatively small number of deaths. Mild scarlatina, or diphtheria, or even small-pox may sweep through a village and be the occasion of only a few funerals. On the other hand, an exceptionally severe outbreak of infectious disease may be attended with a fatality out of all proportion to the number sick, and thus become the source of erroneous inferences. So that it seems eminently desirable that a registration of diseases should in some way be put into operation, not to take the place of mortality-registration, but to supplement it.

To the public, as well as to the health-authorities, an accurate knowledge of the prevailing diseases is of evident value. An official bulletin, issued at stated intervals, declaring what acute diseases are present in a specified section, and in what part of that section they are most rife, has a double usefulness: it warns well people to avoid the risk of exposure in any specially infected locality, while it prevents the ill effect of sensational items, which are ever on the alert to startle newspaper readers by their alarming assertion that this or that dreaded and dangerous malady is "raging" in some community which is only measurably affected, or, it may be, is wholly exempt. If it were possible to publish daily records of the relative prevalence of the more important acute diseases, and of their comparative gravity, from returns gathered and compiled upon authority, the people might escape the apprehension and the alarm fostered by paragraphs for which nobody is responsible.

The analogy between such a scheme and the already established system of weather-reports will at once occur. The eminent usefulness of the work done by the Signal Service cannot be gainsaid. Its value to commerce, to agriculture, and to the conduct of ordinary affairs, has been fully tested. The "weather probabilities" have become an important feature of the daily news, and thousands of people are accustomed to shape their plans according to the prognostications of the chief of the bureau. Already we have intimations of

a greatly extended operation of the system of weather-reports begun so successfully in this country; the time will presently come, when an international bulletin of meteorological observations, taken simultaneously at many stations in the northern hemisphere, will furnish special means for the development of this department of scientific study.

In like manner, the prevalence of endemic and epidemic diseases may be registered. Large areas of territory may be included in the field of observation, and bulletins issued by a central authority may give timely warning of the rise and spread of zymotic affections. Just as the "cautionary signal" now tells the mariner or the traveller that a storm is coming, so in the future will the official word of the registrar tell the public of the existence of infectious and contagious diseases, their gravity, and their progress. Indeed, it is not too much to predict that "probabilities" may yet be cast with some degree of precision, as we advance in our knowledge concerning epidemics. The manifold directions in which such a system may prove useful in gathering facts concerning epidemiology, in staying groundless alarm, in pointing out localities to be avoided, in indicating specially threatened places, need hardly be mentioned farther.

Yet it must be confessed, that there are many and serious difficulties *at present* in the way of a practical realization of such a plan. Some of these obstacles are inevitable; others would disappear as time introduced more perfect methods of registration, and diminished the friction of new machinery. It is proper to allude briefly to some of these hindrances.

It is obvious that the registrar of prevalent diseases is obliged to depend for his working material upon the medical profession; his information must come from physicians upon whose punctuality and uniform fidelity the success of the entire business relies. The law is not his ally in this matter, as in the case of the kindred registration of mortality; the labor attending the gathering of the preliminary facts must, therefore, be entirely voluntary and public-spirited. But it is impossible that the entire medical profession, including all persons styling themselves "doctors," could be enrolled in the service; and on many accounts it is well that it is so, because, as is amply illustrated in mortality registration, the

certificates furnished by the numerous company of pretenders, to whose ministrations a pretty large minority of the people submit themselves in times of sickness, are of doubtful value, and do not supply reliable data for sound reasoning. A purely ideal system for registering prevalent sickness would involve the recording of every case of acute disease, whether it were under the care of persons representing one or another degree of medical skill, or indeed of those without any degree at all. Such a comprehensive plan, even supposing it to be desirable, is not practicable. Reliance must therefore be placed upon a selected number of observers, who will regularly return the required facts. The registrar will aim to secure the coöperation of the best physicians, those at once the most accomplished and the most busily engaged in their art. He will be fortunate if those of his first choice do not decline his overtures, through reluctance to accept another draft upon their professional charity and good-nature. Any scheme of this sort will be strong, and its results valid in proportion to the trustworthiness of those who are its practical supporters; success depends more on the character of the observers, than upon their number. The first difficulty, therefore, in the way of this registration, is the selection of men best fitted to perform the primary service; the second and greater difficulty is to enlist these volunteers in the corps of observation.

But supposing the corps to be sufficiently and satisfactorily filled, the physicians composing it representing the best possible quality as regards medical intelligence, extent of observation, fidelity, the next obstacle lies in the fact that the matters to be reported upon are not of an absolute character. The meteorological observer is sure of his weather record; his thermometer, and barometer, and anemometer indicate to him positive conditions, about which there can be no mistake, the proper precaution being taken, of course, concerning the accuracy of the instruments. But the clinical observer deals with matters far more subtle and difficult; the reliability of his record of observations depends upon his own acuteness and judgment. He reports the presence or absence of diseases whose diagnosis is not always easy. His opinion of the nature or gravity of any case or series of cases may be quite

different from that of his neighbor. What is diphtheria to one observer, is croup or simple sore throat to another; what is febricula to one, is typhoid fever to another; what is cholera infantum to one, is infantile diarrhœa to another; what is influenza to one, is bronchitis or severe catarrh to another. For this diversity there is no radical remedy. It is the source of a considerable margin of error in the registration of mortality, affecting the causes of death; it is the possible origin of a still wider range of uncertainty in the results of any scheme for registering diseases which do not afford, in their fatal termination, an additional indication for diagnosis. Our chief safe-guard is again to be found in the known skill and reputation of the observers.

The liberality of the State Board of Health permitted during the year 1875 a plan for registering prevalent diseases in Massachusetts to be subjected to a practical test. The plan was not a pretentious one: it was offered as an initiatory experiment in a field of sanitary statistics hitherto unproductive. The purpose was to break the ground, in the hope that other workers might be tempted to carry forward and perfect a project believed to contain undeveloped elements of value and importance to the public welfare. It is the main object of this paper to report what has been done, the methods, and the results.

For the purposes of the plan devised, the State of Massachusetts was divided into seven sections of unequal size, but of distinctive topographical characters. The hill country of Berkshire formed one section. The second region comprised the counties of Franklin, Hampshire, and Hampden, the "valley" section, traversed and drained by the Connecticut River. The county of Worcester constituted the third or "midland" section. The "north-eastern" section included all of Essex County, and all of Middlesex County except eleven towns and cities embraced in the fifth section. This latter, the "metropolitan," contained Boston and its suburbs, the northern boundary being the valley of the Mystic River, and the southern the Neponset River. In this section were included, besides the city proper, with its recently acquired outlying territory, the following: Hyde Park, Brookline, Newton, Watertown, Belmont, Cambridge, Arlington, Som-

erville, Melrose, Medford, Malden, Everett, Winthrop, and Chelsea. The "south-eastern" section, the largest in area, consisted of the counties of Norfolk (the towns of Hyde Park and Brookline excepted), Bristol, Plymouth, and Barnstable. The islands of Martha's Vineyard and Nantucket constituted the seventh, or "island" section. These several territorial divisions were made without regard to their extent, or to the distribution of their population, but solely with reference to their general characters, as regards situation and surface.

The field of observation having thus been divided, the physicians were selected in each district to perform the part of observers. The principle of the choice has been intimated. The aim was to secure the coöperation of regularly educated, intelligent medical men, whose field of practice was so distributed as to enable them in the aggregate to give a comprehensive and accurate weekly conspectus of the diseases prevalent in the entire State. In cities whose sick poor were attended to by means of an organized gratuitous dispensary service, the physicians of the visiting staff were regarded as particularly desirable reporters, for the reason that the patients under daily observation were so numerous, and of such a character, as to have considerable influence in determining the relative prevalence of acute diseases in their localities.

The project was introduced to the attention of the profession in November, 1874, the following circular being mailed to one hundred and sixty-eight regular physicians:—

COMMONWEALTH OF MASSACHUSETTS.

STATE BOARD OF HEALTH, }
BOSTON, NOV. 1, 1874. }

DEAR SIR:—The State Board of Health is very desirous of getting weekly information of the diseases prevalent in all parts of Massachusetts. The object is certainly one of great importance,—positive knowledge of the health of the people, as well as of the diseases which, at any time and place, are present, or which threaten to extend as epidemics.

In order, however, to attain this end, the board will need the coöperation of a large and select number of physicians, in full general practice, in various parts of the State. We therefore take the liberty of asking whether you will consent to be one of this

number,—to report weekly, during the next year (1875), the diseases prevalent in your vicinity. The inclosed sample postal card will indicate the proposed method; it will be observed that an endeavor has been made to reduce to the minimum the expenditure of time and trouble incident to the service asked of busy medical men.

The board has appointed Dr. F. W. DRAPER, of Boston, to be the registrar of this new Bureau of Health Correspondence. He will compile from the returns received a concise weekly bulletin of prevalent diseases, to be reported to the secretary of the board, and published, with appropriate comments, for the information of the people. At the end of the year, a summary of the accumulated observations will be prepared for publication in the annual report of the board.

If the board is successful in securing the coöperation of physicians in the accomplishment of this plan, the practical results will be of essential value, not only to the State at large, but to private individuals. To medical men, in particular, such a weekly synopsis of prevalent diseases would be possessed of obvious interest. It is not out of place to remark, also, that the present scheme is the first practical attempt in any part of the world to make a systematic weekly registration of diseases. It is hoped that you will consent to assist the board in executing a purpose which is capable of being developed to very useful ends. If you will please to signify your willingness to undertake the service alluded to, the proper blanks will be forwarded.

We have the honor to be, very respectfully, yours,

HENRY I. BOWDITCH,
DAVID L. WEBSTER,
J. C. HOADLEY,
RICHARD FROTHINGHAM,
T. B. NEWHALL,
R. T. DAVIS,
CHAS. F. FOLSOM,

Members of the State Board of Health.

To this preliminary request for coöperation, one hundred and fifteen physicians responded affirmatively. In March, 1875, this number was increased by the enlistment of the aid of seventy-nine additional physicians. These one hundred and ninety-four medical men were supplied from time to time with postal-card blanks, to be filled and forwarded to the

registrar. This blank form, of which a copy is here given, was intended to procure the maximum of information with the least amount of machinery and detail.

F. Report of Diseases prevalent
during the Week ending
Saturday, ... 1875.

63 Please erase the names of Diseases NOT prevalent, and indicate the relative gravity of PREVALENT diseases by a cross (X) under "Mild" or "Severe," as the case may be; basing the Report, not alone on the actual cases in the reporter's practice, but also on a general knowledge concerning his vicinity. Please mail the card as soon after FRIDAY of EACH WEEK as is convenient.	Bronchitis.	<i>Mild.</i>	<i>Severe.</i>
	Cholera Infantum .		
	Cholera Morbus . .		
	Croup (<i>Membraneous</i>) .		
	Diphtheria		
	Diarrhœa		
	Dysentery		
	Influenza		
	Measles		
	Pneumonia		
	Rheumatism		
	Scarlatina		
Small-pox			
Typhoid Fever . .			
Whooping-cough .			
.....			
.....			
.....			

Remarks.

.....

.....

M. D.

If more particulars had been called for, necessitating an additional outlay of time and thought on the part of the active practitioner, much less would have been gained in the end. The form has served admirably throughout the year. Future experience may indicate the time when more elaborate data can be asked for and obtained; the point has not yet been reached when a state commission can draw from an overworked profession long-continued gratuitous service, unless that service

be of the simplest nature, and to secure most useful ends. It is a pleasure in this connection to testify to the faithfulness and uniformity with which the physicians have discharged their promise to coöperate in this work. It was to be expected that some would fail and drop out of the ranks before the year was ended; but to the large majority, the registrar feels indebted for well-sustained assistance. Without this aid, the plan would have come to naught; to it the experiment owes nearly the whole of its success. If one would seek for some sign that the registration of diseases is a desideratum, and that the present method has in it some quality of favor, he might find such evidence in this ready response and long-sustained support on the part of many of the best representative physicians of the State.

The reports returned at the end of each week were assorted by districts, the initial letter at the left upper corner of each card being designed to facilitate that work. The diseases reported by each section were then compiled from the cards, and a percentage computed between the number reporting each disease and the whole number reporting for that week for that district; thus, if from the midland section, in a given week, twenty-five (25) cards were received, of which eighteen (18) returned pneumonia as prevalent, the percentage for pneumonia for that week and that section would be seventy-two (72). Inasmuch as the number reporting from week to week necessarily varied somewhat, this computation of the percentage would appear to show better than any other way the relative changes in the prevalence of diseases. All the sections having been analyzed in this way, the summary for the State at large was obtained in a similar manner by aggregating the returns. The results of the analysis for each section and for the State were transferred to charts, which presented to the eye a graphic picture of the prevalence from week to week of acute diseases, the regular curves giving a satisfactory notion of their development and decline.

One feature of the work, and that by which the public has known of its progress, has been the weekly bulletins. From the cards, and from the charts, was readily made a brief summary, setting forth the diseases prevalent in the various parts of the State, with a comparative record giving the increase or

decline of the more dreaded affections. This weekly bulletin was published simultaneously on Thursday mornings throughout the year in the "Boston Medical and Surgical Journal," and in the Boston "Morning Journal." A single specimen will suffice to show the general character of these announcements:—

"The following is a bulletin of the diseases prevalent in Massachusetts during the week ending January 16, 1875, compiled under the authority of the State Board of Health, from the returns of physicians representing all sections of the State:

"In Berkshire, pneumonia, rheumatism, bronchitis, and typhoid fever. Diphtheria and croup are less prevalent.

"In the Connecticut Valley, bronchitis, influenza, rheumatism, diphtheria, pneumonia, whooping-cough, and croup; scarlatina is less prevalent. One physician in Springfield reports meningitis.

"In the midland section, mild bronchitis, severe pneumonia, influenza, rheumatism, whooping-cough, scarlatina, and diphtheria. Erysipelas is reported as 'epidemic' in the northern part of Worcester County.

"In Middlesex and Essex counties, influenza, bronchitis, scarlatina, rheumatism, pneumonia, and whooping-cough. Measles and diphtheria are subsiding.

"In the metropolitan section (Boston and its suburbs), bronchitis, pneumonia (not fatal), rheumatism (sub-acute), measles, scarlatina, influenza, and whooping-cough. Diphtheria and tonsillitis appear to be subsiding together.

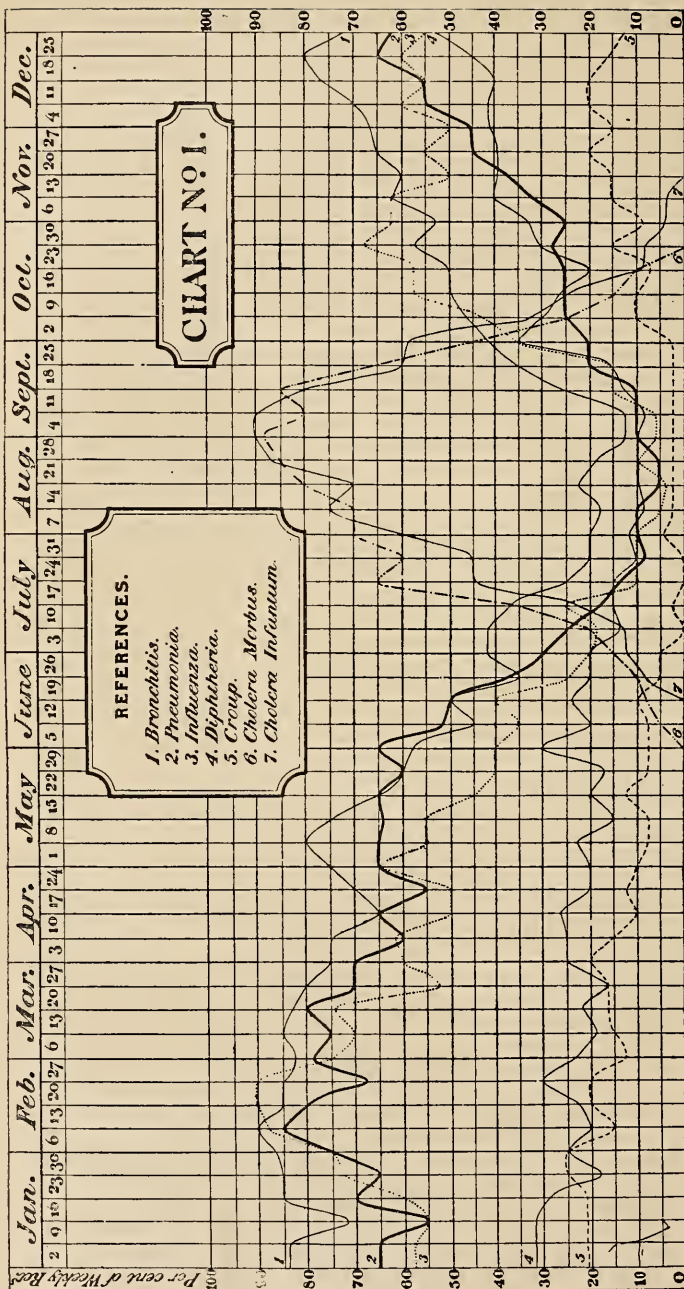
"In the south-eastern counties, mild bronchitis, influenza, pneumonia, rheumatism, whooping-cough, and croup. Scarlatina is less prevalent.

"It appears that bronchitis, pneumonia and rheumatism prevail in all parts; croup and diphtheria are most prevalent in the Connecticut Valley; scarlatina is in the midland, north-eastern and metropolitan sections, its type being generally mild; whooping-cough prevails mostly in the rural sections.

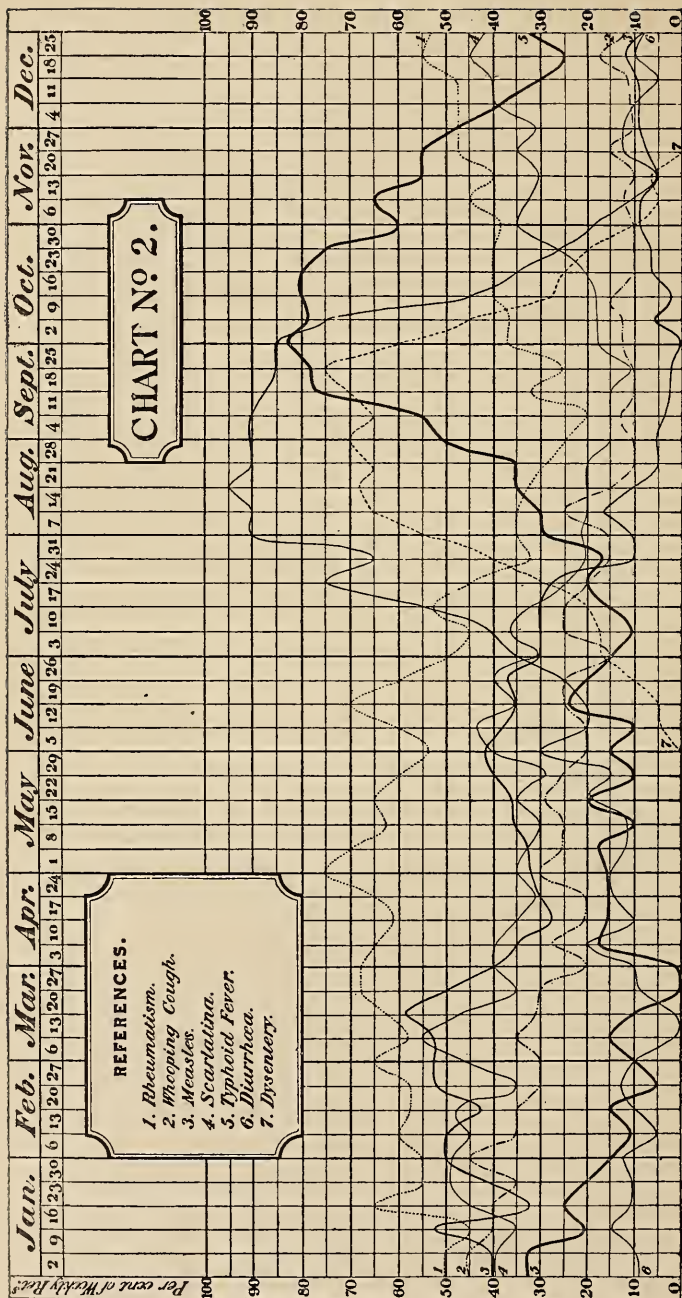
"Since last week there has been a decline in the following: Measles, diphtheria, and tonsillitis. Bronchitis, influenza, pneumonia, rheumatism, scarlatina, and erysipelas show an increased prevalence. Croup and whooping-cough are the same as at last report.

"F. W. DRAPER, M. D., *Registrar*."

But the weekly statements do not exhaust the account of the fruits which the scheme has made apparent; the bulle-



NOTE.—This chart is to be read as follows: "For the week ending January 2, 1875; 84 per cent. of the observers returned bronchitis as prevalent; 65 per cent. reported pneumonia; 57 per cent. reported influenza; 32 per cent. reported diphtheria, &c."



tins served their purpose, and fulfilled their end, as soon as they were published; they were essentially ephemeral. It is possible to gather from the returns some results of a more permanent value. The geographical distribution of non-fatal diseases, their development considered with relation to the changes of the seasons, their more or less distinctly defined local manifestation, their relation to meteorological variations, are all capable of being demonstrated. The accompanying charts are intended to show the relative prevalence of acute diseases in the State at large during the year. It will be useful to add a few notes concerning the different sections whose charts are not introduced.

Berkshire.—During January, croup and diphtheria were quite prevalent; but they subsided as the spring advanced, and remained absent until October, when a slight accession occurred. Influenza and bronchitis were present throughout the winter and spring months, but they disappeared before the first of June, to reappear in late autumn; pneumonia and rheumatism followed a similar course. There was some typhoid fever in the first three months of the year; it disappeared in April, to return in September, and continue through the autumn. The diarrrhœal diseases of summer began their invasion at about the first of August, considerably later than in some of the more populous sections; they subsided in the second week of October. Whooping-cough was never entirely absent. Measles had a very limited course during February, March, and April, and it reappeared in some parts in December. Scarletina was present (but not prevalent) during April, May, and June. In April, the town of Lee reported the presence of small-pox.

The Valley of the Connecticut.—This section began the year with bronchitis, diphtheria, pneumonia, and rheumatism as its prevailing diseases. In February, bronchitis was joined by influenza, and both held sway till the middle of March, when they subsided together, reaching their point of least prevalence in midsummer, but returning with October, and continuing to prevail quite generally during the rest of the year. Diphtheria was at no time wholly absent; it was most prevalent in January, least prevalent in August; from the first of October to the close of the year it was again quite rife,

especially in the cities and larger towns. Pneumonia and rheumatism kept their course together from January to June, when the former subsided while the latter continued; after the first of October both diseases increased in prevalence till the end of the year. Measles had a limited course in January and February, and again in May and June, but it was never epidemic, as in some of the more eastern parts; in the late autumn, the town of South Hadley suffered from the combined presence of measles and diphtheria. Scarlatina maintained its hold throughout the year, but it was only moderately prevalent. Small-pox was reported in the spring by a few towns (Holyoke, Easthampton, Wilbraham, Huntington), but the disease did not extend. The summer diseases (diarrhœa, dysentery, cholera infantum, and cholera morbus) first appeared in the last week in June, reaching their maximum prevalence in August, and disappearing in October, diarrhœa being the first to enter and the last to leave the stage. Typhoid fever was first reported in the last week of July; it steadily advanced till the last week of September, and thenceforward it declined; in the towns along the banks of the river a remittent type of fever was observed. Cases of cerebrospinal meningitis were reported in the earlier months of the year as present in the northern parts of this section (Shelburne, Ashfield, etc.).

Midland (Worcester County).—Bronchitis, influenza, pneumonia, and rheumatism held the highest place in the scale from January to June; measles and scarlatina came next in the list, the former reaching its highest point in February, and continuing till August, the latter having its maximum in March, but prevailing to a limited extent throughout the year. Whooping-cough was reported through January, February, and March. Typhoid began in the last week of July, and was most abundant in October; it held the highest place in the list in that month. Diarrhœa led the van of the summer maladies, beginning in June, and followed a fortnight later by dysentery, cholera morbus, and cholera infantum, their maximum prevalence being in August and September. In October, bronchitis and influenza reappeared coincidentally with the occurrence of epizootic catarrh. Several towns in the Blackstone Valley reported small-pox at the close of win-

ter, and in the spring. Millbury reported an unusual number of puerperal fever cases in May. "German measles" (rötheln) was frequently observed in the spring.

North-eastern.—The diseases of the respiratory organs (bronchitis, pneumonia, and influenza) held sway till June, when they subsided, to return in October, and continue to the end of the year. Measles and scarlatina were very general throughout the earlier half of the year, and the autumn witnessed their revival. "German measles" was frequently reported in the spring. Whooping-cough was prevalent during the first six months, but it disappeared in midsummer. Rheumatism kept its hold throughout the year. Diphtheria was more common during the last three months than at any other time; it was not as rife in this section as in some other parts of the State. The last week in July was the time at which the diseases of summer began; their highest point was reached in September; their disappearance occurred in the last week of October. Typhoid fever commenced in August, was most prevalent in September, and declined in October. In the spring, isolated cases of cerebro-spinal meningitis were reported as present in certain towns in Essex County. The year has not been an unhealthy one in this section; influenza, measles, and scarlatina have been the only diseases which had a prolonged or very general prevalence.

Metropolitan.—The first returns of the year indicated the prevalence of bronchitis, measles, pneumonia, rheumatism and scarlatina. These diseases kept their place at the head of the list until June. In February they were augmented by an epidemic of influenza, which continued till the middle of May. Scarlatina reached a high point in March, then subsided during the summer months, to return in October, and to become more prevalent in December than at any time during the year. Diphtheria secured a hold early in the year, declined somewhat in the spring and summer, but reappeared in September, and was quite rife from that time until the end of December. Tonsillitis was common during the first quarter. Whooping-cough prevailed to a limited extent during the first four months. The group of summer affections began to develop in the last week of June, was most rife in August, and subsided in the early part of October.

Typhoid was never absent during the year ; its increase began in the middle week of August, the highest place being reached in the middle of October ; it was not as prevalent here as in some of the rural sections. At the close of the year, bronchitis and pneumonia headed the list of prevalent diseases, and diphtheria and scarlatina came next in order. R  theln prevailed quite generally in the spring, accompanying the epidemic of measles, and appearing in this section before developing elsewhere. Epidemic catarrh occurred in October, coincidently with the epizootic disease.

South-eastern.—Bronchitis and influenza were rife from January till June. Pneumonia and whooping-cough prevailed extensively from February to April. Diphtheria was present from January to April, and again in the autumn, its maximum being in October ; it was less prevalent than in most other parts of the State. Measles prevailed in March, but not at any time so extensively as in the metropolitan and north-eastern sections. Scarlatina was present during the first six months, and again in the last quarter, but not extensively. July witnessed the accession of the diarrhoeal diseases, August their maximum prevalence, and October their decline. September and October were the months in which typhoid fever was the most rife. In March and April, small-pox was in Fall River, but it did not extend.

The towns upon the islands in Martha's Vineyard have been comparatively exempt from acute diseases throughout the year.

The charts of the various sections enable us to trace the wavelike progress of contagious diseases. It is made apparent that the strictly contagious affections do not assail large areas of territory coincidently, but that their invasion is progressive. Thus, measles was epidemic in Boston in January, February, and March ; it was hardly mentioned in the returns from the north-eastern and the south-eastern section before March, and while it was subsiding in Boston, it was most abundant to the north and the south of that city. March, April, and May found it in the midland section, while May and June were the months in which it was most prevalent in the valley of the Connecticut.

Cerebro-spinal meningitis occurred sporadically throughout

the year in all the sections ; but it did not have, at any time, or in any place, a very marked prevalence. Many of the observers noted its coincidence with bad drainage and other unsanitary conditions.

The distinction of diseases, according to their type, as mild and severe, has been observed by those making the weekly returns. It is impossible in this summary to make use of this discrimination, but in the course of the year it has been very useful in determining the relative gravity of the various affections in regard to time and place. It may be stated in a general way, that in all parts of the State, the year through, the milder forms of acute diseases have predominated.

The sensitiveness of the public health to weather-variations has been shown repeatedly by means of the weekly returns. A sudden change in temperature or in humidity, has again and again indicated its effect upon the amount and gravity of the prevailing diseases. A single instance, which many persons in Massachusetts will recall, may be cited as an example of this. The fourth week in April, the week in which the centennial celebrations at Concord and Lexington occurred, was marked by a severe cold snap after an interval of mild weather. The sickness returns for the week represented a very decided increase of acute diseases ; bronchitis, influenza, rheumatism, pneumonia, whooping-cough, measles, scarlatina, and sore throat were returned as being much more prevalent. It is one of the advantages of such a system of sickness-registration that it shows at any time, and without delay, the effect of weather-changes, making a far more prompt and satisfactory exhibition of the influence of such changes upon the public health, than is possible with the mortality-table which gathers the more distant, indirect, and partial results of the same phenomena.

It is to be remarked, in conclusion, that the method of sickness-registration, tested in Massachusetts during the last year, has surpassed the expectations of many who were interested in its trial.* Experience has discovered certain defects

* When it is remembered that the State contains a population of 1,651,912 persons, living in 19 cities and 322 towns ; that the average weekly number of physicians who have reported in season for the published bulletin, concerning the prevalent sickness in all these cities and towns, and of all these

in it, which, in future, might be avoided. The year's work has demonstrated the willingness of the medical profession to coöperate in such a registration, and this fact alone is a significant result of the trial. It is to be hoped that the recording of prevalent diseases may yet become as indispensable a department of the public service as is the registering of mortality at the present time. It matters little what the details of the method are, or who originates them, if only they are practicable, and their results are good. The need of such a record is undeniable; its fulfilment is a question of time. In the words of a distinguished leader in sanitary reform, "Registration of deaths represents the wrecks which strew the shore, while that of sickness would tell us of the coming storms, and enable us to trim our vessels to meet them. Till we have such a system of disease-registration, public health cannot be administered with full intelligence."*

people, has scarcely reached six scores, and that these physicians have based their returns, not on data of absolute statistical accuracy, but on their general knowledge of what was going on around them, the results of the year's experiment may seem insignificant to the critical. It is frankly admitted that the results of this single year's work are without much value in themselves, but it is insisted that the method of registration should not be judged according to the fruits of this short period of trial. Two measures at once suggest themselves for rendering the plan more effective in future, and both these measures are practicable: first, to enlarge the number of weekly medical reporters; and, secondly, in proportion as that is accomplished within the limits already alluded to, to call for statements which shall more fully satisfy the requirements of statistical correctness. When the fact is recalled, that the registration of vital statistics has required more than a quarter of a century to attain its present place, it can scarcely be expected that any registration of sickness can come full panoplied into being, or that its first fruits will be entirely satisfactory.

* Right Hon. Lyon Playfair, F. R. S. Address on Sanitary Reform. 1874.

HEALTH OF BOSTON.

1875.

By F. E. OLIVER, M. D.

HEALTH OF BOSTON.*

The somewhat confused state of the registration department, arising from contemplated changes in the mode and management of the mortality registration, has made it a little difficult to obtain an accurate estimate of the mortality of Boston for the past year. As the only returns for the whole year are those of the registrar, these have been adopted, although not entirely accurate, the number of deaths registered by him for the last seven months of the year falling considerably short of that contained in the tables of the City Board of Health.

It appears from the returns of the city registrar that the number of deaths in Boston, in 1875, was 8,954, this exceeding by eleven hundred the number recorded in the previous year, an increase that may be, in part, attributed to the unusual length and severity of the winter, together with extraordinary epidemic influences during the latter part of the year. With a population that may be fairly estimated at 342,000, we have accordingly a death-rate of 26.18 in the thousand living, which is an increase of 2.59 per thousand over

* An attempt was made to compare the mortality of Boston during the past year with that of 1870, using for that purpose the census of 1875, and the "health-districts" into which the city had been subdivided by the late Dr. Derby. It was found, however, that the records of the city registrar did not contain information of sufficient exactness to make it advisable to publish a report based upon those returns.

For that part of the year during which the City Board of Health has preserved the records, statistics of great value have been preserved in a manner to make them accessible and thoroughly to be relied upon, for the first time in the history of Boston. It was hoped that the erroneous results reached in the paper on the mortality of Boston could be rectified, by means of comparison with the accurate records of the Board of Health. It was found, however, at a late day, that this was impossible within the limits of time allowed the writer, and the board regret to be compelled to withdraw a paper of value. The following report, originally prepared for the "Health of Towns," is commended by the board to that careful consideration which the reputation of the writer and its thorough research deserve. [ED.]

that of 1874, and of 1.63 over the estimated mean death-rate of Boston. In the mortality tables of the City Board of Health for the seven months ending December 31, 1875, there are 79 more deaths recorded than appear in the returns of the registrar, which, added to those already quoted, give 9,033 as the whole reported mortality for the year, and a death-rate of 26.41; and for Boston, exclusive of the three recently annexed towns, 26.80 per thousand. By further excluding Roxbury and Dorchester, the death-rate rises to 28.32, which is not far from four per thousand above the mean death-rate for Boston previous to the annexation of these five towns.

The high death-rate that has characterized Boston for some years past, is largely due, as is shown in the recent report on the Sanitary Condition of Boston, to the excessive mortality among infants and children under five years of age, the mean death-rate under one far surpassing that of London, and almost equalling that of Liverpool, the most unhealthy of English cities. The year that has now closed is by no means an exceptional one in this respect, the death-rate of infants under one being somewhat above, although that of children under five falls a little below, the mean for the last four census years. The rate above five was also 2.7 per thousand above the mean for the same years, as also considerably above the mean decennial death-rate for London, as appears from the following table:—

DEATHS IN BOSTON PER THOUSAND LIVING.	1855.	1865.	1870.	1875.	Mean of the four Census years.	London, mean of ten years—1851- 1860.
Under 1, ...	-	265.5	276.9	275.8	272.7	-
Under 5, ...	99.4	99.2	97.2	86.8	95.6	78.0
Over 5, ...	14.7	15.6	15.5	18.8	16.1	16.6
At all ages, . . .	25.4	23.6	24.3	26.1	24.8	23.7

The diseases that have been most prevalent are phthisis, pneumonia, and three diseases of the zymotic class,—scarlatina, diphtheria, and cholera infantum, to which may be added typhoid fever.

The mortality from phthisis, which was somewhat higher in the first and fourth quarters of the year, was less by seventeen than in the previous year; the percentage of deaths to the whole mortality falling to 14.90, or 3.86 to the thousand living, which is less than the mean death-rate from this disease for the last ten years, and pretty nearly corresponds with the mean decennial death-rate throughout the State, and marking a still further decline in the mortality from this disease, which has for some years been steadily decreasing. The

highest number of deaths (five per thousand) was in the twenty-third district, which comprises the northern slope of Beacon Hill, including the narrow, crowded streets at its base lying between West Boston and East Cambridge bridges. The northern side of this hill is inhabited largely by a colored population, and from its northerly exposure, and the nature of the soil, is cold and damp. From the analysis of the mortality statistics given in the report of the Commission on the Sanitary Condition of Boston, above referred to, it is shown that the high rate of mortality from phthisis is in a great measure due to the large Irish population, who show a marked proclivity to lung affections.

The deaths from pneumonia numbered 666, or more than 100 more than in 1874, and 7.43 per cent. of the whole mortality. This disease was especially fatal in the first quarter of the year, and its prevalence was probably due to the cold and prolonged winter; the average temperature for the first three months being 25.2, which is six degrees lower than during the same period in the previous year. The largest number of deaths was in district 23, where the death-rate was 2.3 per thousand. The lowest mortality was in district 28.

The large mortality from scarlatina and diphtheria was due to epidemic influences, not unaided by local causes, which will be alluded to below. The number of deaths from scarlatina was unusually large, amounting to 530, or 5.91 per cent. of the whole mortality. It was especially fatal in districts 20, 21, 35, 39 and 42, where filth and foul air have for years been allowed to do their legitimate work unmolested. The highest rate of mortality was in Brighton (district 45), where the death-rate was six in the thousand, not an improbable cause of which is suggested by one of our Brighton correspondents.

The deaths from diphtheria gradually increased from 49 in the first three months of the year to 234 in the last quarter, amounting to 418 for the whole year, and making 4.66 per cent. of the entire mortality, and a higher death-rate from this disease than ever before here recorded. The highest mortality was in districts 38 and 45. No deaths were reported from district 26. Deaths from membranous croup, which was more prevalent than usual, are not included in this estimate. The death-rate from the latter disease was 0.64 per thousand, or 2.45 per cent. of the whole mortality, being nearly double the mean for the previous ten years.

There were 680 deaths from cholera infantum, which is one more than the number recorded in 1874. These occurred mostly from June to October, inclusive, the highest weekly number being in the first week in August. The districts where it mostly prevailed

were those where it has been observed in previous years,—in overcrowded parts of the city, exposed to every insanitary condition. No case was reported from district 28.

The mortality from all the diarrhœal diseases taken together, including the last mentioned, was 999, which is not far from one-ninth of the whole mortality for the year.

The deaths from typhoid fever were 225, or 2.51 per cent. of the whole mortality, the number reported for the last half of the year being nearly double that of the first six months. Many of the cases are believed to have been imported from the country.

The mortality from the prevalent zymotic diseases, taken together, mainly due to scarlatina, diphtheria and the diarrhœal diseases, although not so high as in 1872, when the small-pox proved so fatal, was considerably above the decennial death-rate from 1865 to 1874, as will appear from the following table:—

Comparative Mortality from Zymotic Diseases in 1875.

DISEASES.		1875.	Mean for ten years.
CHOLERA INFANTUM,	Deaths per 1,000, ...	1.98	1.92
	Per cent. of mortality, ...	7.59	7.81
DIARRHŒAL DISEASES,	Deaths per 1,000, ...	0.93	1.03
	Per cent. of mortality, ...	3.56	4.19
SCARLATINA, ...	Deaths per 1,000, ...	1.55	0.93
	Per cent. of mortality, ...	5.91	3.85
DIPHTHERIA, ...	Deaths per 1,000, ...	1.22	0.21
	Per cent. of mortality, ...	4.66	0.86
MEASLES, ...	Deaths per 1,000, ...	0.18	0.13
	Per cent. of mortality, ...	0.70	0.52
WHOOPING-COUGH, ...	Deaths per 1,000, ...	0.08	0.20
	Per cent. of mortality, ...	0.32	0.82
TYPHOID FEVER, ...	Deaths per 1,000, ...	0.65	0.66
	Per cent. of mortality, ...	2.51	2.64

It is to a few diseases of this class, as has been shown by the able report above referred to, that is largely due the high death-rate of Boston for many years past. More than one-fourth part of the entire mortality the last year is attributable to these diseases; and, as they are believed to be especially promoted by insanitary conditions peculiar to certain localities, the testimony of physicians was requested as to how far they were able to trace the influence of these conditions in the cases that had fallen under their observation. The circular addressed to them contained the following questions:—

1. *Have diphtheria, scarlet fever, and typhoid fever been, in your*

experience, more prevalent or not during the past year than in the preceding year or years?

2. *Have you had reason to regard these diseases as due to defective drainage or the presence of sewer-gases in the particular locality where they have appeared, or in its immediate vicinity?*

3. *Has cholera infantum been especially prevalent during the past summer, and what were the insanitary influences that seemed to you to promote it, or the three above-named diseases, whether in connection with locality, absence of sunlight, defective drainage, overcrowding, or insufficient water-supply, etc.?*

4. *Please give the localities, including street and number, where you have had cases of the above diseases, and where they have been most prevalent?*

Of the physicians who replied to the above questions, there are many who were unable to perceive any connection between these diseases and the conditions referred to. By far the largest number, however, including many of wide experience, regarded their influence on diphtheria and typhoid fever as unquestionable. How far such influences affected the development of scarlet fever, there seems to be a more equal division of opinion. The fact that this disease not unfrequently occurred in places where no local cause could be assigned, may be readily explained by its communicability, and the constitutional proneness that exists in some individuals to zymotic diseases.

The following are quotations from the letters referred to, so far as our limits will allow:—

Diphtheria.—Dr. Bickford, of Charlestown (district 46), after mentioning the alarming prevalence of diphtheria, says, that “nearly every case that I have seen, has occurred in houses with defective drainage which, in this district, is fearfully bad in all houses which have been built from twenty to forty years, or more. They were laid on planks which have become decayed and broken away, allowing the drain to become clogged and the cellars to become filled with the fluids from sinks and water-closets.”

Dr. Campbell, of East Boston, writes, that “the most malignant cases of diphtheria and scarlet fever occurred in localities where the drainage is imperfect, although not entirely confined to those places.”

“I have, for a year past,” says Dr. Cheever, “had recurrent (many times) cases of sore throat in a family of children, in Montgomery Street, which have wholly ceased since a defect in the soil-pipe was discovered and remedied.” “I have just lost a patient (three months old) after five days’ sickness of an obscure character, but pointing to some obstruction of the throat, and death from exhaustion, in East Chester Park, where sewer-gas is a daily nuisance in the wash-bowls,

and where, in summer, the Roxbury Canal, quite adjacent, has been unparalleled in vileness." Dr. Cheever also mentions "a case of slow and recurrent pneumonia in an infant who, during its sickness, was suddenly seized with vomiting its milk. The milk was prepared and kept in an open bowl, set into the water of the wash-bowl to keep it cool. Over this played a stream of sewer-gas from the overflow pipe—very perceptible; vomiting ceased when the food was removed, the overflow hole puttied up, and the bowl kept full of water."

Dr. Edes states that "the typhoid cases and the diphtheritic croup that he had seen, occurred in a badly drained district."

Dr. Hastings "has noticed more diphtheria and typhoid fever in parts of the city where drainage is imperfect."

Dr. Blood, of Charlestown (district 46), says: "In regard to diphtheria and typhoid fever, I believe the cause of all the cases that I have seen, without exception, to be defective drainage, the presence of sewer-gases being noticeable in or about the houses where the cases occurred." "I would not speak so strongly in regard to the cause of scarlet fever."

Dr. J. B. Ayer mentions cases as occurring at Portland Street (144), where the common sinks contained a great deal of refuse, and often emitted offensive odors. "In Myrtle Street (121), where the odors from the cesspools in the yard were very offensive, and the cellars so foul, that the tenants threatened to leave." "In Porcelain Place, where the cesspool occasionally sends up offensive odors; also offensive at high water."

Other cases are mentioned where no odors were noticeable, or where no inquiry was made as to their existence.

Dr. Nichols, of Roxbury, states that in his experience, "these diseases were decidedly more numerous, and the results less favorable in those districts imperfectly drained, or subject to the action of sewer-gases, or the emanations from the so-called midden-vaults."

"I have noticed," says Dr. Osgood, "for many years, that the above diseases have been much more severe in consequence of these gases, and in some cases, I believe, they were caused entirely by them."

Dr. Whittier attributes these diseases to "both defective drainage and the presence of sewer-gases." A paper was read by Dr. Whittier before the Society for Medical Observation, in October last, which gives four cases of this disease, where these influences were unmistakable in their effects.

The following extract is from a letter of Dr. Goss, of Roxbury:—

"I was called to see, some time in January, a child who was suffering from this disease, in Williams Street, where a child had

died of supposed diphtheria,—not a very severe case. Later in the year, the father had a severe attack of pneumonia, but recovered; still later, a child was taken with the same disease, and died. The mother, who was confined in September, had a tedious convalescence from pelvic cellulitis and other complications. This house is situated in what was formerly a marsh, or a part of a territory comprised in the Roxbury Flats. It is far below the level of the street, with no proper facilities for drainage, and water is standing, much of the time, under the house. I cannot affirm that the unfavorable location of the dwelling had anything to do with the cases of disease occurring therein, but am convinced that this, and many others in its vicinity, are built where habitations should not have been permitted until proper arrangements had been made for drainage.”

Dr. C. D. Homans remarks that he has found no special cause for the few cases that he has seen, but “the drainage is defective everywhere.”

Dr. Hyndman says: “I have had no reason to attribute the disease to either of the above-named causes.” He subsequently states that his practice chiefly lies in the “*north part of the city.*”

Scarlet Fever.—Dr. J. B. Ayer mentions cases of this disease in Cusson Place (2), where the drains empty into the water-closets on each floor, and are often very offensive in summer. “In Cambridge Street (193), where the odors from the drains were very offensive through the summer and early part of the fall; often most intolerable. In Anderson Street and Bridge Court, where the water often rises in the cellar, but without odor.”

Dr. Bush states that “the cases of this disease that he had seen occurred in crowded houses, in Middlesex Street, a part of the city that is considered well drained, so far as the street is concerned, but the pipes in the house were insufficient for the amount of work required of them, so that parts of the houses were in a foul condition.”

Dr. Fisher mentions a house in Fabian Street where there were three cases and two deaths, and where “the surroundings are not as wholesome as they should be.”

Dr. Morrill states that he has had cases of scarlet fever “which seemed to point directly to bad drainage as the only cause, this existing both in the exact locality of the disease, and in its immediate vicinity.”

Dr. Street attributes this disease, as well as diphtheria, “to defective drainage, more than to any other cause beyond the control of the tenants.”

Dr. Giddings, of Brighton, in allusion to the remarkable prevalence of scarlet fever in that district, where it has proved far more fatal than in any other portion of the city, says: “I am unable to

account satisfactorily for the outbreak of scarlet fever. We have no system of drainage, and cases have occurred with as much frequency in localities where elevation, slope, and soil would favor the disposition of extraneous matters, as in those where the surroundings would seem to favor and perpetuate the poison. There is one fact worthy of note, which may furnish an hypothesis by which we may account for the production of this disease. There is a low, flat piece of land (a sort of semi-meadow) lying along the south line of the Boston & Albany Railroad in Allston. During the fall of 1874 a large amount of compost from a slaughter-house was spread over this low land, and, for a time, for the distance of a mile or more, according to the direction of the wind, the most pungent and sickening and offensive odors prevailed. From that time to the present, scarlatina has prevailed, with an occasional case of diphtheria. I am forced to believe that, from this compost spread over this low land, the poison of scarlatina and diphtheria originated, and has been continued, by the diffusion of the poisonous gases and the principle of contagion."

Dr. Marion, of Brighton, states that he has seen scarlet fever in nearly every street in the district. "The epidemic began here in December, 1874, and raged through the winter months. Through the spring and summer there were only isolated cases. In September, 1875, it commenced again, and continued to increase till January, when it seemed to be at its height. Since then it has been gradually disappearing. In the winter of 1874-75 it was confined mostly to the more elevated portions of the town; during the past winter mostly to Allston; North Beacon Street might be considered the dividing line,—scarlet fever raging south of it in 1874-75, and north of it in 1875-76. During the year I attended one hundred and fourteen cases; of these sixty-three were of Irish parentage."

It will be noticed that the date of the outbreak of scarlet fever corresponds with that given by Dr. Giddings.

Typhoid Fever.—Dr. J. B. Ayer reports a case of typhoid fever in the rear of Spring Street (21), where the cesspool was under the privies, and where the odor in summer was strong enough to require the closing of the windows.

Dr. Belt, of South Boston, thinks that most cases "can be traced to defective drainage from houses to the street."

Dr. Blodgett thinks that the absence of any subterranean drain in a small, sunless court, was an important factor in the causation of the disease.

Dr. Minot mentions a case of this disease "in a boy eleven years old; one of obscure disease, with symptoms of nervous and physical prostration, lasting several months; and two or three cases of slight

indisposition, all occurring in the same family, which were supposed to be caused by sewer-gases escaping from a defect at the junction of the soil-pipe with the house-drain, discovered after the house was vacated."

Dr. Shattuck reports several cases "which appeared to be due to defective drainage."

Dr. Tarbell states that about one-fourth of the cases of typhoid fever that have come under his observation could be traced directly to some local origin; one-fourth only indirectly, and in the remaining half there could certainly be no such cause assigned.

Dr. Walker, of South Boston, mentions "two severe cases, which occurred among the attendants at the lunatic hospital, both of which were attributed to exposure to a foul drain while cleaning and repairing it."

Dr. J. C. Walker mentions "a case of this disease on Highland Park Avenue, where the location was high. The patient had not been into the country, and the disease seemed to be one arising from defective drainage. There was no sewer-drainage in the street."

Cholera Infantum. A very large proportion of the cases reported are believed to have been due to one or more of the causes mentioned in the following extracts from the letters of our correspondents:—

1. "Long-continued and excessive heat, acting on children who have been nourished on artificial food, in crowded and badly ventilated rooms, exposed to decaying animal and vegetable matters, bad drainage, putrefying excrement, and water contaminated with putrescent animal matter; especially soakage from privies.

2. "Offal thrown out of tenement-houses, being allowed to remain and decompose."

3. "Very hot weather in conjunction with unsuitable food and contaminated air. Absence of sunlight, defective drainage, and overcrowding, as also privies and swill-pails."

4. "Overcrowded, dark, badly drained houses."

5. "Overcrowding, absence of sunlight, improper food, improper clothing, want of cleanliness, bad sewerage and carelessness in the removal of refuse matter."

6. "Errors in diet (of 200 nursing-bottles carefully examined, but 20 were proved free from fungi)."

7. "A filthy house."

8. "Defective drainage, locality, overcrowding, in so far as this also implies filth; absence of sunlight."

9. "Overcrowding and improper feeding."

10. "Defective drainage, defects in water-closets, and stagnant water, as in open lots."

11. "Exhalations from filth-water."

12. "Exposure to the heat of a cooking-stove in rooms in the second and third story."

13. "Teething infants fed artificially, bad food, and overcrowding in streets and courts deficient in light and air."

14. "Bad drainage and improper food."

The localities where the above diseases principally prevailed are the same that have long been noted for high mortality rates. Those especially mentioned are districts 20, 21, 22, and 23, corresponding to the old wards 1, 2, 3, and part of 4; districts 29 and 30 to ward 7, which comprises the South Cove territory and parts of South Boston; and districts 35, 39, and 42, comprising wards 10, 13, and 15; also district 45, or Brighton, where scarlet fever proved so fatal. Many of these districts contain either a dense population, crowded into dark, narrow streets, or are characterized by *low, wet* or *ill-drained* land; and the inhabitants are largely composed of foreigners whose habits and proclivities especially predispose them to diseases of the zymotic class. The insanitary influence of new-made land is not apparent, as the highest death-rate reported (31 per thousand) was in district 21, which is upon the original soil, while the healthiest district, 28, is one, the larger part of which, a few years since, was covered by the waters of the Back Bay.

The above testimony is less important as showing a connection between certain insanitary conditions and a dangerous and fatal class of diseases, now generally recognized, than as pointing out the results of defective sanitation at our own doors, and the urgent necessity of such sanitary measures as in many foreign cities have proved so effectual. With a mortality as reported for the past year of 1,200 above the average mortality, that average itself being considerably above the normal death-rate of Boston, as shown by the report above referred to, and with all the facts and recommendations of two commissions before them, an unenviable responsibility rests upon the city authorities, should the warning pass unheeded.

The number of deaths in public institutions was 907, or not far from one-tenth of the whole mortality.

In connection with this subject, it would be amiss not to mention, however briefly, the recent reports of the two commissions just alluded to, one on the Sanitary Condition of Boston, and the other upon the Sewerage of Boston, appointed a year ago or more, under the auspices of the City Board of Health. The publication of these papers, drawn up with admirable care and ability, may be said to mark an era in the sanitary history of Boston, for it cannot be doubted that the suggestions contained in them will receive that attention which the character of the commissioners and the importance of the subject entitle them to:

The first-mentioned report includes a careful analysis of the mortality statistics, showing that the death-rate, which has been thought for some years past to be excessive, is due, in a great measure, to the large mortality among infants and children, as well as the large foreign element, especially Irish, in our population. Nearly two-thirds (58.4 per cent.) of the aggregate population, it is shown, are composed of foreigners and their offspring, of which large proportion two-thirds again (64.6 per cent.) are Irish, who are peculiarly prone to those diseases which act so large a part in swelling our mortality lists. Among these may be mentioned phthisis, pneumonia, Bright's disease, and certain zymotic diseases suggestive of defective sanitation, and appropriately termed "filth-diseases," the latter including cholera infantum, the diarrhoeas, and typhoid fever. That portion of the second chapter treating upon the Influence of Nationality upon mortality is of especial interest, as is also the third chapter upon the "Nature and causes of the diseases which occasion our excessive mortality." In allusion to the sanitary needs of Boston, a more complete and accurate system of registration is recommended, and such sanitary measures as shall more effectually counteract the morbid causes that occasion one-fifth of all the deaths that take place, and which are shown to be removable. The most important of these measures is suggested in the following paragraph, which we quote at length:—

"The prevention of filth-infection, in its various forms, constitutes, without any doubt, the greatest and most urgent sanitary need of Boston. The attainment of this end imperatively calls for the adoption of energetic measures designed to prevent all possible contamination of our air, water and food, by the putrefying organic matters of all kinds which constitute 'filth.' Dirt has been defined as 'matter out of place'; so the filth, of which we speak, is but sewage out of place. When confined within its proper channels, and therein, constantly undergoing rapid removal, sewage is harmless, and does not deserve the opprobrious epithet which it incurs under opposite conditions; namely, when stagnating without, or even within, its channels; then poisonous vapors are generated and given off, which convey filth-infection in all its forms.

"By no other means can the purification of our city from filth be encompassed, than *by the rapid and continuous removal* from our midst of all refuse matters, such as constitute sewage, comprising solid and liquid excrements, foul household waters, etc., etc. Any reliance upon 'disinfectants,' as a means of public sanitation, would be but a delusion and a snare."

The appointment of the Commission on Sewerage was in compliance with a request of the City Board of Health. It had long been believed that there is a direct connection between decomposing matter and disease, and the experience of foreign cities had shown that, with an improved system of sewerage, sickness and mortality

had much diminished. It was thought that the time had come when Boston should have a system of drainage commensurate with the necessities of a great and growing city. "The evil of the present system of sewerage chiefly arises," says the report, "from additions being constantly made to the territory of the city, and from the sewers being necessarily extended through these low districts, and on flat grades, without a definite, comprehensive system." Many of them are insufficient for the work required, and others are so low that they cannot be emptied even at low tide. In other cases, there are no tide-gates, the sewers lie low, and the soil is incompletely drained, the cellars are often wet, and the sewer-gases are driven into the houses by the rise of the tide. It is also stated that "twenty millions of gallons of sewage are discharged daily at different points, completely skirting the city, and polluting the atmosphere throughout most of its length and breadth." The plan suggested by the commission is to carry the sewage far out into deep water, where its discharge will be remote from dwellings, by two enormous sewers extending from a point near Cottage Farm Station to the sea, on either side of the city; one to run in a south-easterly direction through the south part of Boston to Moon Island, and the other north-easterly through Cambridge, Charlestown, Chelsea, and Winthrop to its outlet at Point Shirley. It was proved, by experiment, that sewage discharged at these points would not return with the tide. With this system there is a constant and uninterrupted flow of the sewage from the time it enters the sewers until its discharge at the outlets.*

* See the map facing page 232; for the "health-districts," see the map facing page 512.

THE
SURFACE-DRAINAGE OF THE METROPOLITAN
DISTRICT.

BY C. W. FOLSOM, C. E.,
OF CAMBRIDGE.

SURFACE-DRAINAGE OF THE METROPOLITAN DISTRICT.

The districts in and around Boston which suffer from imperfect surface-drainage are of two classes: *salt-water* or *tide marshes*, and *fresh-water marshes*, swamps, or lowlands.

The *salt-water marshes* are of uniform character, composed of soft alluvial mud, with a surface-level of from ten to eleven feet above mean low water, rendering them always liable to be flowed at spring tides.*

Such salt-water or tidal marshes can, of course, only be drained by diking out the tide, and providing for the escape of any streams running down from the highlands by diverting them over the embankment, or allowing them to escape through self-acting tide-gates, or valves, at low water; in which way the ordinary water of rains over the marshes themselves would escape. In marshes of large area, pumping might be found necessary, as in Holland.

The *fresh-water marshes*, or lowlands, occur on almost all the brooks and rivers in this district, at all levels from their sources to their mouths, where they join the salt marshes (that is, in the vicinity of Boston, from 200 feet above the sea, downwards). In most instances they are of natural formation, but many of them are increased or aggravated by the flowing of mill-dams, as on the Charles and Neponset rivers.† Most of them are at such a level above tide as to render their drainage perfectly simple and generally easy, the fall of the streams below them being such as not to involve long or heavy cuttings for that purpose; but, owing to the fact that the land is held in small parcels, it would generally be impossible for the owner of a marsh to drain it except by entering on his neighbors' lands below him; for which reason, some general system, conducted, under legislative authority, by some central

* These range, in Boston harbor, from ten to twelve and a half feet above mean low water, and are even higher in exceptional storms. The height of the tide in the great storm of April, 1851, which carried away Minot's Ledge light-house, was about fifteen and one-half feet.

† See paper by Dr. George Derby, on "Mill-dams," and the evils caused by them, in the Report of the State Board of Health for 1872, pages 60-70.

power, would seem to be the only way in which drainage can be accomplished.

The evils of all these marshes, in a sanitary point of view, are chiefly as follows :—

1st. Houses cannot be built on them in their undrained condition without *wet cellars*, a well-recognized source of disease.

2d. The *air over them*, and for a considerable distance around, is *damp*, from excessive evaporation ; a further cause of diseases such as consumption, rheumatism, neuralgia, etc.*

3d. A certain amount of *malaria* exists, from the decomposition of wet vegetable matter in warm weather, perhaps not generally sufficient in this latitude to create intermittent fever in those who are free from its seeds, but bringing it out in those who have contracted its taint in other States or countries, and probably affecting the general health of many in a similar way, but in a less marked form.

Much land that is not ordinarily called “ marsh ” is subject to the above evils. The immediate valleys of the streams may be of firm soil, and not marshy at ordinary seasons ; but being scarcely or not at all above the level of the water in storms or spring freshets, it follows that all houses built there must be subject to wet cellars at those times. And so great is the difficulty of making an ordinary cellar perfectly water-tight, even with cement, with a constant head or pressure of water forcing its way in from the outside, that it is at best imperfect sanitation to build a house with the bottom of the cellar below the level of the water-table in the adjoining land.

The only cure for the evil of a marshy soil for building purposes that has been tried around Boston hitherto, has been by a simple raising of the ground by filling. The area of filled land in the metropolitan district has been roughly estimated at about 3,300 acres, or five square miles. Many districts † have been raised by the city, after they had become thickly inhabited, at an expense of several millions of dollars.

In case of fresh-water marshes, the proper cure lies in the lowering of the water-table in the soil by thorough drainage previous to building, and even previous to any filling that may be thought desirable. This drainage may ordinarily be effected by open ditches, protected in very loose soils by stoning the sides at bottom. If, owing to the thick crowding of houses, or the improvement of the

* See the article by Dr. H. I. Bowditch on Consumption, in the Report of the State Board of Health for 1873.

† For instance, in the vicinity of Church, Dover, Suffolk and Northampton streets in Boston, and of Washington, Sparks and Cowperthwaite streets in Cambridge.

land for garden or farm purposes, it becomes necessary to cover the water-courses, it may be effected by using dry stone culverts for the larger streams, often best supplemented by a filling of loose stone above the culvert, or by the common, unglazed, agricultural draining-tile for the valleys at the heads of streams. Tight brick or vitrified pipe-drains, if laid in cement, though excellent for carrying off the water when it has once got into the drain, cannot be well used for receiving and collecting the water from the soil. Common sewers, if properly built for their use as such, are not suitable for this purpose, unless for carrying off the water from loose drains above them; because, for use as sewers, they should be built as tight as possible; whereas, for the drainage of bogs and swamps, the drains should be open or loose in character for the whole length of the swamp, so that the surface-water may be quickly absorbed and carried away. The sewers, too, have generally to follow the lines of the streets, which are very rarely laid out lengthwise of the valleys of the streams, that being the place to which drains for surface-water should converge to be efficient.

It is impossible, in the limits of this Report, or without more detailed surveys, to indicate, except in the most general manner, the position of the places needing drainage. The whole districts of the "Back" and "South" bays, so called, in Boston, are familiar to every one. It is to be hoped that no portion of these lands in future filling will be left at the objectionable levels which have formerly prevailed; but it is worth considering whether more effort should not be made towards keeping the tide-water out of the subsoil after they are filled than has ever yet been done. It is to be remarked, that a large part of the lands which have been filled or raised in the suburbs, particularly in Cambridge and Somerville, are barely filled to high-water mark of spring tides. Before really good drainage or sewerage can be insured, it will be necessary to raise these lands very considerably higher.

The whole valley of "Stony Brook" in West Roxbury and Dorchester districts, with an area of water-shed, including small portions of Hyde Park and Brookline, of 8,000 acres, or $12\frac{1}{2}$ square miles, can be drained by the city of Boston, under existing acts of the legislature.* On the upper portions of this stream are some of the worst swamps in the city of Boston. We would particularly mention as needing drainage on the waters of Stony Brook, the district in Dorchester bounded by Erie Avenue, Washington Street, Norfolk Street, and Blue Hill Avenue; and in West Roxbury, the district bounded by Morton, Back, Walk Hill, and Canterbury streets;

* See chapter 196 of Acts of 1874; chapter 220 of 1870; chapter 223 of 1868, etc., etc.

also, that bounded by Washington, Williams, and Forest Hills streets; also, that bounded by Centre and South streets and the Bussey Farm. Very many other places in Dorchester and West Roxbury require drainage, in the thickly settled as well as in the wilder portions. In Cambridge, Somerville, and Arlington there are considerable areas requiring drainage of the soil along the course of Alewife Brook.

Abstract of Areas of Upland and Lowland for Boston and Neighboring Towns, taken from the Report of the "Commissioners on Annexation," being City Document No. 105 of 1873.

	Area of Upland,— Acres.	Area of Marsh or Low Lands,— Acres.	Total Area, not in- cluding streets,— Acres.
Boston in 1873, ...	7,575	2,008	9,583
West Roxbury, ...	6,500	127	6,627
Brighton, ...	1,970	400	2,370
Charlestown, ...	340	198	538
Total Boston in 1875, ...	16,385	2,733	19,118
Cambridge, ...	2,415*	1,045*	2,983
Somerville, ...	2,312	50	2,362
Brookline, ...	3,500	500	4,000
Watertown, ...	2,312	55	2,367
Medford, ...	4,400	520	4,920
Winthrop, ...	697	185	882
Everett, ...	1,450	650	2,100
Revere, ...	2,100	1,300	3,400
Chelsea, ...	400	620	1,020
Total, ...	35,971†	7,658†	43,152

* The sum of these is 3,460 acres, which includes 477 acres of streets.

† The sum of these is 43,629, which includes 477 acres of streets.

In this paper there has been no attempt to treat the subject of surface-drainage in an exhaustive manner; the remarks here offered, necessarily confined within a narrow limit, are simply meant to be suggestive of the general importance of the matter, and of the need of attention to it by the cities and towns of the Commonwealth. The facts stated in this report are illustrated by the accompanying map.





- Salt Marsh
- Low and swampy
- Filled

Mile Scale

MAP OF BOSTON.



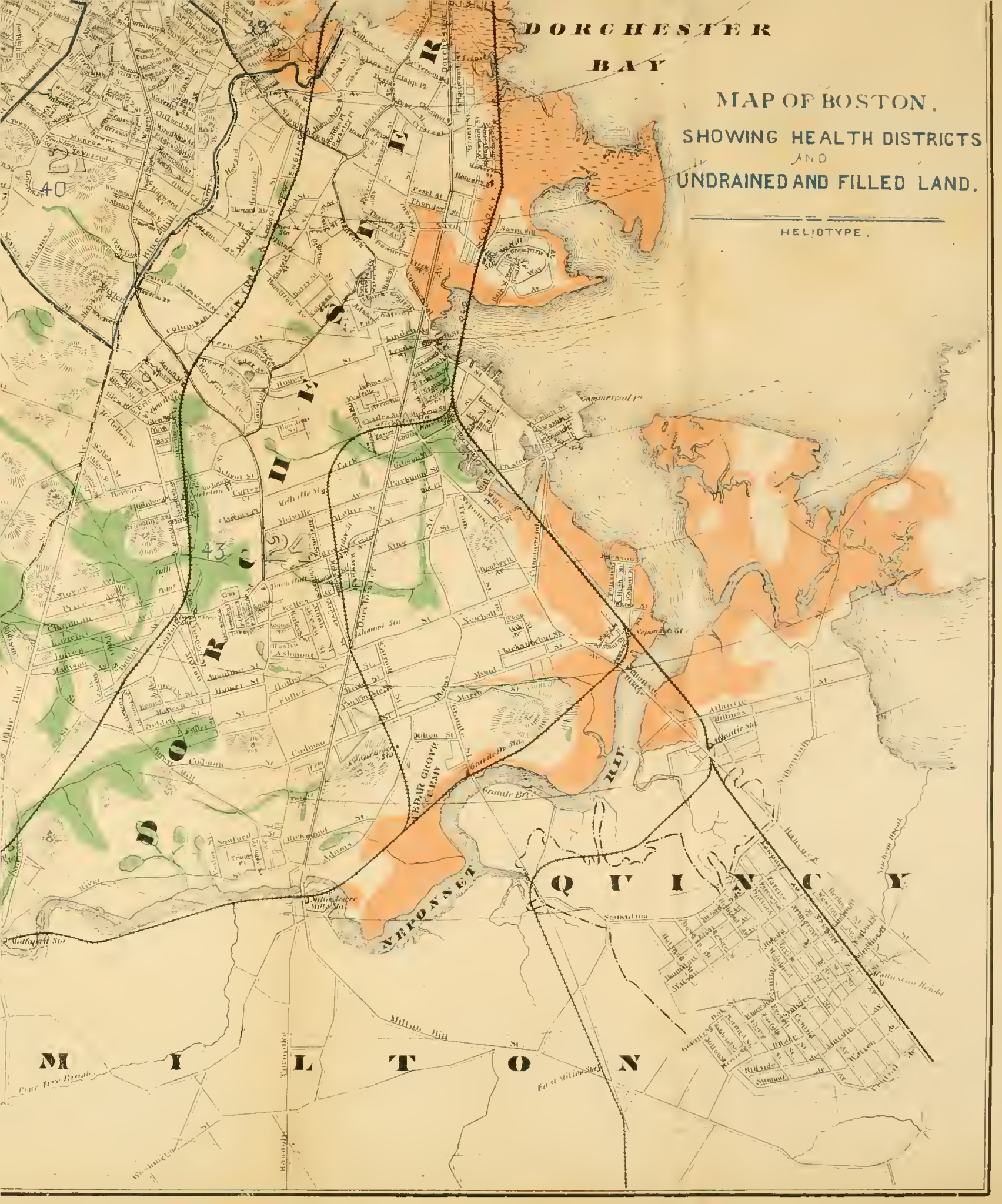
DORCHESTER

BAY

MAP OF BOSTON.

SHOWING HEALTH DISTRICTS
AND
UNDRAINED AND FILLED LAND.

HELIOTYPE.

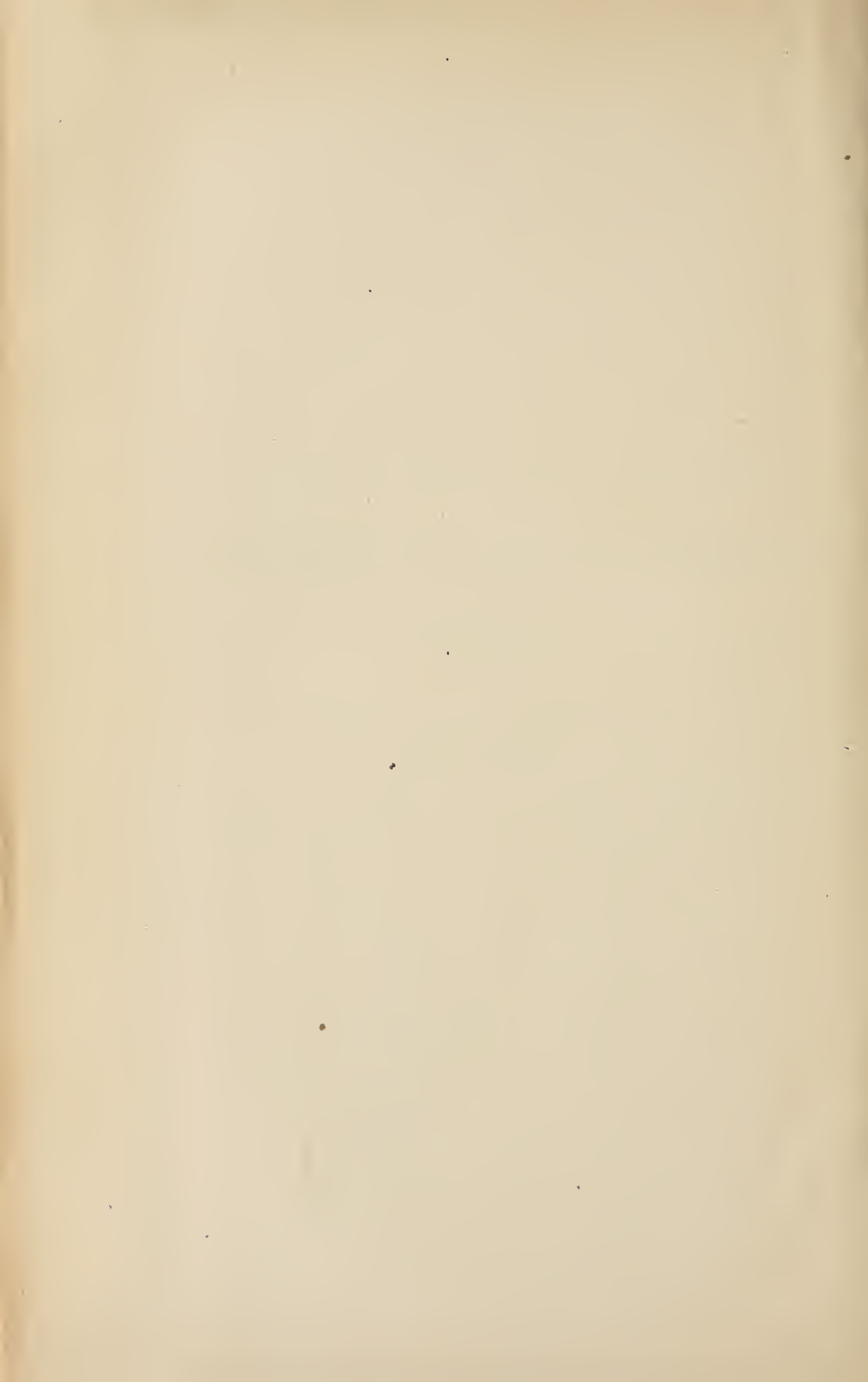


THE HEALTH OF LOWELL.

1875.

BY F. NICKERSON, M. D.,

OF LOWELL, MASS. ,



THE HEALTH OF LOWELL.*

It is the general belief here, that the health of the city during the past year has been unusually good. The correctness of this belief is, in part, demonstrated by the following statistics taken from the reports of the city physician, and of St. John's Hospital.† It must be borne in mind that the population of Lowell has been increased by 1,100, the past year, through annexation:—

DEATHS IN LOWELL.	1874.	1875.
Whole number of deaths, ...	1,184	1,017
Deaths from typhoid fever, ...	42	29
from scarlet fever, ...	100	19
from cholera infantum, ...	135	104
from consumption, ...	184	213
from pneumonia, ...	61	51

Cases Treated at St. John's Hospital.

Whole number of cases treated, ...	280	217
cases of typhoid fever, ...	34	18
of consumption, ...	29	21
of pneumonia, ...	14	10
of rheumatism, ...	15	12

The numbers of deaths in the city from consumption, in 1872 and 1873, were 225 and 207, respectively.

The character of typhoid fever has been less severe than usual; and several physicians have observed, this fall, a diminished tendency to intestinal symptoms. In 1872, the number of deaths from

* This paper was originally prepared to be published under "Health of Towns"; but there are so many suggestions of importance as applying to other cities in the State, and as showing the need of establishing in them boards of health, that it is given here separately.

† The writer desires to express his indebtedness to many medical gentlemen, and especially to the city physician, for information embodied in this report.

this disease had reached 66. Water was introduced in January, 1873. Since then, the record has been as follows: 1873, 56 deaths; 1874, 42; 1875, 29. In St. John's Hospital there have been treated: 1872 (from April 1 to January 1), 68 cases; 1873 (the whole year), 39 cases; 1874 (the whole year), 34 cases; 1875 (the whole year), 21 cases.

The epidemic of scarlet fever may be said to have ended early in the year. The cases have been scattered, and generally mild.

There has been no small-pox.

Board of Health.

The Lowell Board of Health is composed of the mayor and one alderman; and, if the mayor declines to serve, of two aldermen and three councilmen. The work of this body is done by the city marshal, who, during the warmer season, employs one or more men to clean out alleys, and attend to such nuisances as may be complained of. No record of these operations has been kept the past year, an omission which I have felt very much, in my attempts to find out how far insanitary surroundings may have been connected with sickness. Since 1871, when the small-pox drove the municipal authorities, at last, into a state of desperate activity, this board has had no history, except in 1872. At this time, one of the members drew up a bill for the establishment of a superintendency of health, at an estimated annual cost of \$1,500. The bill was rejected, on account of the expense. The income of the \$27,000 just received by this city from licensed victuallers, would meet this estimate.

Diphtheria.

The Lowell mortuary record for croup and diphtheria, from 1846-76, is as follows:—

YEAR.	Diphtheria.	Croup.	YEAR.	Diphtheria.	Croup.
1846-1861, .	0	19, 26, 41, 19, 12, 18, 16, 29, 47, 34, 33, 23, 10, 24.	1866, . .	18	20
1861, . .	1	31	1867, . .	11	14
1862, . .	15	22	1868, . .	3	14
1863, . .	39	26	1869, . .	7	23
1864, . .	34	12	1870, . .	3	28
1865, . .	7	12	1871, . .	8	15
			1872, . .	7	20
			1873, . .	4	21
			1874, . .	17	34
			1875, . .	16	39

By these figures, it is observed: (1.) That, in some years which preceded 1861, the mortality from croup was far above the average. (2.) That no mention is made of diphtheria till 1861. These peculiarities are explained by the fact, that, several years ago, what we now call diphtheria, received the name of diphtheritic croup, which was registered croup. In the bills of mortality of Lowell at the present time, the term diphtheritic croup is not used at all. In 1863 and 1864, according to the list of deaths, and the testimony of some of the older physicians, there was an unusual amount of epidemic sore throat.

During the foregoing two years, there has been prevailing, more or less, in our city, an epidemic influence that has been productive of affections of the throat, which have been classified variously as tonsillitis, diphtheria, and croup. All the fatal disease of this class has been registered under the latter two heads. This epidemic influence, of which I have just spoken, has been much more marked since the last of September; all but four of the registered deaths of diphtheria, this year, took place in this period.

The first cases of diphtheria, which were brought to my notice, this year, occurred in the last of September, and in October, on Fayette Street, near the corner of Chestnut Street. Here, in a house on the moist, rich, sloping bank of the Concord, live two families, who have no association with each other. Family No. 1 occupies the ground floor on the street. In this family were two cases, one of which proved fatal, October 3. The odor from the vault is powerful, and peculiarly nauseating. Behind the house is a damp garden, which is sometimes overflowed by defective drains from neighboring dwellings. In the basement, farther down the slope, in a still damper situation, lives family No. 2, in which were three cases and one death, September 20. Under the sitting-room is an unventilated and unlighted cellar, four feet deep, where hens had been kept; a drain passes under the floor of the main sleeping-room. The smell of the vault which adjoins the room in which the deceased child lay sick, was so strong, at that time, that the doctor ordered the removal of the patient to another part of the house. Both these families use well-water. Farther down the slope, on the very edge of the river, reside an old man and his wife. The latter having attended the deceased child of family No. 2, was taken, on the day after its death, with symptoms of diphtheria. The overflowed garden, above mentioned, adjoins this house. The vault is cleanly; city water is used. The sewage from these three tenements, as well as from those about to be noticed, passes first into a neighboring cesspool, and then into the river above its surface, where the odor is marked. On the opposite side of Fayette Street is a house

which was occupied, but has been vacated by families A and B. In 1872, there emptied into an open cesspool, two feet square, and situated in the cellar, ten sink-pipes. The cesspool overflowed, so that the cellar was constantly covered with sewage, the odor from which penetrated the house. Family A then consisted of five members, two of whom had typhoid fever, and one died. In family B, which numbered four, three had the same disease, and one died. After this, the number of sink-pipes was reduced to two. Family B vacated in due time. Family A remained, and was recruited to its original number by the birth of a child. The drain in the cellar was still a very perceptible nuisance, and the vaults were, at times, very offensive. The father died of typhoid fever last June, and two children died of diphtheria last October. Well-water was used here, in 1872; now, city water.

This part of Fayette Street has been for a long time notoriously unhealthy. The houses are crowded together on the side of a muddy hill. There is no proper sewer in the street. The vaults and sewage have been frequent sources of complaint. Intermural spaces, which are used as receptacles of all sorts of filth, are numerous, and the habits of the people are dirty.

Recently, in some courts a few rods below the locality which I have been just describing, there have been three or more deaths from diphtheria, and several persons are now sick with it. In a certain house there were three cases and one death. Here I found a dark alley, two feet wide, into which sewage was emptying and passing through the interstices of a crumbling stone wall, into a damp, ill-ventilated, and dark cellar.

The quarter known as Centralville is in the north-easterly part of the city. It is divided by Bridge Street into East and West Centralville. The former is situated mostly on high ground, and is healthy. The latter is on low ground, and is, for the most part, poorly drained and unhealthy, especially in the lowermost portion, whose general boundaries are as follows: On the north, a line drawn from Bridge Street through the line of West Fourth Street to West Street; on the south, the Merrimac; on the east, Bridge Street; on the west, West Street. Although a sewer has recently been built through River Street, most of this section drains into the meadow of which it is composed, and into a brooklet passing through it. Many houses are built directly over this stream, which is turbid in some places with the contents of vaults, etc. In the course of this stream have occurred at least twenty cases of sore throat, and three or four deaths, this fall.

The space bounded by Hildreth Street on the north, east by Jewett Street, south by West Sixth Street, and west by Coburn

Street, is a plateau which helps to drain the springy hills above Hildreth Street. It has been only recently settled; the houses are not crowded; the inhabitants are intelligent. The soil consists of loam, which rests either on sand or hard-pan. The drainage is all on the surface. This fall, on Coburn Street, in a house whose sink-drains emptied into the well, there was a fatal case of so-called typhoid fever, and in the same region where the sewage flows in streams about the houses and into the cellars, there was a case reported as croup, which recovered. On the corner of West Sixth and Coburn streets, were two cases of diphtheria, one of which resulted fatally October 22. The house stands on the verge of a meadow, twenty or twenty-five feet above it,—within a distance of twenty-five feet passes a surface drain-pipe which emitted bad odors previously to the deceased child's sickness. In another house on West Sixth Street, there were three cases. The first child, A, was taken sick October 28. She had been playing with one of the children who was afterwards taken sick in house No. 1. The mother of A had attended the funeral of one child in house No. 1 October 24. B was taken October 28; C, November 2; and D, November 8; no deaths.

In house No. 3, on Jewett Street, a little girl died of diphtheria November 11. This girl had stood over the death-bed of the child in house No. 1, and had associated with child B a good deal, even while the latter was sick.

In house No. 4, on Jewett Street, in rather a low situation, lives a family, who have had no association with the other families. The land on which the house stands is filled in with six inches of refuse from the city. The family in question occupy two rooms on the ground floor; viz., a sitting-room about 13 feet square, and an adjoining bedroom about 10 by 9. The ceilings of these rooms were completely covered with brown stains, which proceeded from a litter of pups kept by a filthy family above, so that the stench at times was very strong. The sink-pipe discharges its contents on the floor of the adjoining cellar. The sink-gutter from the tenement overhead passes over the roof of the piazza and opens over the sitting-room below, and deposits strongly smelling water, which has worn for itself a hollow, three feet from the well. The white paint of the house, in the vicinity of the gutter, is blackened with the sulphurous emanations. The solid excrements of the dogs, etc., were thrown under the window of the sleeping-room. The well is fifteen feet from the sewage in the cellar, and is covered with boards, on which it was the custom of the upper family to clean spittoons, etc. Some specimens of the water were drawn, and sent to Prof. Nichols for analysis. At the time the first specimen was taken, the depth of

the well was eleven feet eleven inches, and of the water five feet eleven inches. The family had noticed the disagreeable taste of the water for some time.* They had lived in the house but a few months before diphtheria appeared, and sickened four out of five persons, one of whom died November 12. The fifth was a babe of five months, at the breast. Of four women who attended the deceased child through its sickness of five days, one who lives in house No. 5, on Jewett Street, was taken with a slight sore throat on Tuesday, November 16. Another, who lives in house No. 6, on Jewett Street, was taken sick, and two children followed; no deaths. A third woman, who lives half a mile distant, escaped; but her daughter was attacked on Monday, November 15, with fever, sore throat, swollen tonsils, and white deposits on the latter. The fourth woman, who lives a mile distant, on a hill in a perfectly healthy locality, where there had been no cases of sore throat, was seized on Wednesday, November 17, with diphtheria; a girl four years old on Monday, November 22; a boy of seventeen years on Tuesday the 23d; husband had sore throat on Sunday the 28th, and also a sister on December 5.

The following table will give some facts as to age, nativity, etc. The numbers included in the braces belong to one family. In addition to the cases thus tabulated, I have learned of the following: In an Irish family of four children, whose surroundings I have not examined, one child died unexpectedly after a week of convalescence. In another family,—Americans, in a healthy region,—an adult died October 30; four children, whose ages range from two to nine, were sick, and recovered. There had been for some time a very offensive discharge of sewage from a leak in the drains in the cellar, which connect with the main sewer. In 1874, a woman in Dracut had the disease (some days, time not precisely ascertained), after inhaling the fumes of an obstructed sewer, which she describes as powerful and nauseating; she recovered. No other cases in the neighborhood. No history of exposure.

* For the analysis of the water of this well, see page 270.

Number.	SEX.		Age.	PARENTAGE.				ATTACK.		Date.	Duration.	Recovery.	Death.	City Water.	Well Water.	REMARKS.
	Males.	Females.		American.	English.	Scotch.	Irish.	Mild.	Severe.							
1	1	—	7	1	—	—	—	—	1	Nov., '74,	—	1	—	—	1	Location very damp—a meadow; water one foot deep in cellar; kitchen adjoins cellar; drainage, surface, and bad.
2	—	1	4	1	—	—	—	—	1	Nov., '74,	—	—	1	—	1	
3	1	—	6	—	1	—	—	—	1	Sept., .	3 weeks,	1	—	—	1	Filthy vault; location damp; drainage not good; girl taken a week after the boy; soil, rich loam.
4	—	1	2	—	1	—	—	—	1	Sept., .	12 days, .	—	1	—	1	
5	1	—	7	—	—	—	1	—	1	Sept. and Oct.	2 weeks,	—	1	—	1	Filthy vault; soil, rich loam; location, on the bank of Concord; drains into river.
6	1	—	9	—	—	—	1	1	—	Sept. and Oct.	—	1	—	—	1	
7	1	—	8	—	1	—	—	—	1	Sept. and Oct.	11 days, .	—	1	—	1	Well fifteen feet from privy; private drain.
8	1	—	3	—	1	—	—	—	1	Sept. and Oct.	1 week, .	—	1	1	—	
9	1	—	7*	—	1	—	—	—	1	Oct., .	2 days, .	—	1	1	—	Cellar damp; drainage bad, also vaults; soil loamy.
10	—	1	1	1	—	—	—	—	1	Oct., .	4 days, .	—	1	1	—	
11	—	1	6	1	—	—	—	1	—	Oct., .	—	1	—	1	—	Drainage, surface; soil, a loam upon hard-pan, just above a filthy meadow.
12	1	—	10	1	—	—	—	—	1	Nov., .	—	1	—	1	—	
13	—	1	40†	1	—	—	—	1	—	Nov., .	—	1	—	1	—	No public sewer; location high; soil rocky.
14	—	1	40†	†	—	—	—	1	—	Nov., .	—	1	—	1	—	

* Months.

† About.

‡ German.

Number.	SEX.		Age.	PARENTAGE.				ATTACK.		Date.	Duration.	Recovery.	Death.	City Water.	Well-Water.	REMARKS.
	Males.	Females.		American.	English.	Scotch.	Irish.	Mild.	Severe.							
15}	-	1	8	1	1	-	-	1	-	Oct. and Nov.	Few days,	1	-	1	-	Drainage, surface; location low, just above a meadow used for drainage; suspicion of contagion in one case.
16}	1	-	6	1	1	-	-	-	1	Nov.,	5 days,	1	-	1	-	
17}	-	1	12	1	1	-	-	-	1	Nov.,	1 week,	1	-	1	-	
18}	-	1	5	-	1	1	-	-	1	Nov.,	4 days,	-	1	-	1	Drainage, surface; location low; soil, loam on sand; probable contagion.
19}	-	1	4	1	1	-	-	-	1	Nov.,	5 days,	-	1	-	1	
20}	-	1	2	1	1	-	-	-	1	Nov.,	1 week,	1	-	-	-	Drainage bad; water bad; location low and damp; cellars damp.
21}	-	1	25*	1	1	-	-	1	-	Nov.,	-	1	-	-	-	
22}	1	-	27*	1	1	-	-	1	-	Nov.,	-	1	-	-	-	
23}	-	1	45*	1	1	-	-	1	-	Nov.,	-	1	-	-	-	A high hill in the country; quite evident contagion; surroundings all healthy.
24}	-	1	4	1	1	-	-	-	1	Nov.,	5 days,	1	-	-	-	
25}	1	-	17	1	1	-	-	1	-	Nov.,	-	1	-	-	-	
26}	1	-	45*	1	1	-	-	1	-	Nov.,	3 days,	1	-	-	-	
27}	-	1	50*	1	1	-	-	1	-	Nov.,	-	1	-	-	-	
28}	-	1	55*	1	1	-	-	-	1	Nov.,	5 or 6 d'ys,	1	-	1	-	Probable contagion; location damp.

29 }	1	6	-	1	-	-	1	-	1	Dec.,	.	5 days,	-	1	1	-	Location just above a filthy meadow; probable contagion from child.
30 }	1	22	-	1	-	-	1	-	1	Dec.,	.	-	1	-	1	-	
31 }	1	6	1	-	-	-	-	-	1	Dec.,	.	4 days,	-	1	1	-	Very damp; drainage and vault bad; cellar with half a foot of water on floor.
32 }	1	12	1	-	-	-	1	-	1	Dec.,	.	-	1	-	1	-	
33 }	1	9	-	-	1	-	1	-	1	Dec.,	.	-	1	-	1	1	Location low and damp; well two feet from drain; no sewer; soil, a rich loam.
34 }	1	7	-	-	1	-	1	-	1	Dec.,	.	1 week,	1	-	1	1	
35 }	1	5	-	-	1	-	1	-	1	Dec.,	.	1 week,	-	1	-	1	
36 }	1	9	1	-	-	-	-	-	1	Dec.,	.	5 days,	-	1	-	1	Low and damp; two drains pass directly by well; cellar dark and ill-ventilated; no sewer.
37 }	1	4	1	-	-	-	-	-	1	Dec.,	.	1 week,	1	-	1	1	
38 }	1	6	-	-	-	1	-	1	1	Dec.,	.	1 week,	-	1	1	-	Crowded; habits filthy; open cesspool; filthy court.
39 }	1	1	-	-	-	1	-	-	1	Dec.,	.	2 days,	-	1	1	-	
40 }	1	4	-	-	-	1	-	-	1	Dec.,	.	2 days,	-	1	1	-	
41 }	1	2	-	-	-	1	-	1	1	Dec.,	.	-	1	-	1	-	
42 }	1	6	-	-	-	1	-	-	1	Dec.,	.	1 week,	1	-	1	-	Low and damp, near filthy brook; habits filthy.
43 }	1	30	-	-	-	1	-	1	1	Dec.,	.	1 week,	1	-	1	-	
44 }	1	7	-	-	-	1	-	1	1	Dec.,	.	2 days,	1	-	1	-	
45 }	1	8	-	-	-	1	-	1	1	Dec.,	.	11 days,	-	1	1	-	Vaults bad; location damp; soil, new rich loam; drainage filthy.
46 }	1	10	-	-	-	1	-	1	1	Dec.,	.	-	1	-	1	-	
Total.	22	24	23	7	4	11	19	27	-	-	-	-	29	17	24	22	

* About.

The epidemic of diphtheria, this fall, though mostly localized, has spread itself throughout the city ; but has been thus far, at least where deaths have occurred, almost wholly confined to insanitary dwellings. Six of the fatal cases occurred in the Fayette Street locality, and six in Centralville. There have also been two deaths from supposed croup ; one in each of these regions.

The following laws have been observed in this epidemic.

1. The disease is contagious.
2. The period of incubation, in the few instances where it could be ascertained with any approach to certainty, was about one week.
3. The attack usually comes on suddenly, with severe constitutional symptoms ; death takes place by obstruction to respiration or by prostration. Convalescence is usually rather slow.
4. There have been no persons older than fifty-five in the families where cases have been observed. In four different families where more than one sickness took place, there were four infants of seven, nine, five, and five months ; of these, the first, who had been weaned from the breast a month before it was seized, died ; the others, who were confined to breast milk, had no symptoms of diphtheria.
5. As in epidemics of typhoid fever and cholera we have a great many "febriculæ" and diarrhœa respectively, so in this epidemic we have had numerous "sore throats," severe and mild.
6. The disease was usually less severe in adults than in children. The average age of decedents was four years and eight months. The maximum age was nine years, the minimum seven months.
7. The records of wind, temperature, and weather give no light as to causation.

The foregoing observations, if they do not point us to the specific cause, sufficiently indicate the direction in which we are to look for the common source and maintenance of this as well as other epidemics that have recently visited our city. In 1871, small-pox found most of its victims among those most neglectful of sanitary laws. In 1872, typhoid fever did its heaviest work in a region flooded by sewage. In 1873, cerebro-spinal meningitis was most rife in the crowded parts of the city. In the same year, scarlet fever was the most virulent in nearly the same region where the typhoid of 1872 had prevailed ; thence it swept the city in 1874 ; and now, in 1875, diphtheria is added to the catalogue of our crimes against the laws of health.

Lowell takes the second place on the list of the most populous cities in this State ; last year she occupied nearly the same numerical position in her death-rate.

HEALTH OF TOWNS.



HEALTH OF TOWNS.

Replies to our circulars have been received from all the cities and from 185 of the 322 towns in the State.

Boston is the only one of the cities which has a board of health other than the officers of the city government. In regard to the rest, our correspondents generally speak of the urgent need of such independent boards. It may fairly be said of the substitutes for them, as was stated in the fourth report of the Board (p. 515): "No doubt can be left on the mind of any one who examines these letters [of our correspondents] that the boards of health of most of the cities and towns of Massachusetts have no idea of the responsibility which belongs to their office." It should be said, moreover, that the selectmen of our towns and the executive officers of our cities have not the time to attend to the duties of health officers, not to mention the fact that they are not especially fitted by education for such work.

In the 185 towns, our correspondents state that the selectmen act as boards of health in 80; that there are no boards in 70 (which is probably equivalent to saying that the selectmen act as such); in 26 it is reported that there are special boards of health; from 9 no report is made. In some of the towns, the selectmen unquestionably do perform and are reported by our correspondents as performing their duties to the eminent satisfaction of all parties. Such cases are the exception, however, and not the rule.

One board of health elected in one of the towns neglected to qualify; in another, an elected board of health is reported as not attending to their duties and as deserving of censure.

We quote from a few of the replies to our circulars, as follows:—

"There is an advisory board consisting of one physician from each ward (five in number). This board gives advice from time to time, which advice is rarely heeded."

"The selectmen of the town constitute our only board of health, and in that capacity have been very quiet."

"There is no board of health. The selectmen act in that capacity when it is unavoidable, but practically almost nothing is done."

"A law should be enacted requiring that there be at least one physician on the board of health of every town and city in the State. The reasons for this are self-evident."

"The board of health are the selectmen. There is no physician a member of that body. These functionaries (the selectmen) give but little heed, as a general thing, to the recommendations of physicians, however judicious, unless such recommendations can be carried out with little or no expense to the town. An intelligent and efficient board of health is greatly to be desired."

"The selectmen of the town constitute a board of health. The fear of losing votes will always prevent a board so constituted from doing the whole of its duty."

"The selectmen of the town are the only authorized board; which amounts to nothing."

"Since the small-pox epidemic, the board of health has been discontinued, and their duties assumed by the selectmen. The expense was assigned as the reason."

In the winter and spring of 1875, acute pulmonary diseases are quite generally reported as having been more prevalent and fatal than usual.

The diarrhœal diseases and enteric fever are thought, by our correspondents, for the vast majority of the cities and towns, to have been less prevalent than usual, or at least not more so, during the year.

Fatal small-pox prevailed in Russell, a small town of 600 inhabitants.

Epidemic influenza was observed quite largely throughout the State, in many cases coincident with the epizootic among horses.

Scarlet fever has been more wide-spread than usual, and more fatal in its results. The chief elements in its spread are evidently contagion and infection; but the evidence of our correspondents, as in former years, goes to show that it assumes especial virulence in the presence of putrefying organic matter; in damp, sunless localities; where the poison is concentrated by overcrowding or other causes; and where the vitality is lowered and the power of resisting disease in the individual is in any way diminished.

Diphtheria has prevailed to a considerable extent throughout the State; in the majority of cases, mild in character, and

occurring only sporadically. The replies of our correspondents are quite full on this point, and we quote from them rather largely.

Undoubtedly, erroneous diagnoses have often been made; and worse than useless alarm has often been caused from confounding other diseases with diphtheria. Many of our correspondents mention this fact, and comment on it somewhat severely. Of course, it is for the interest of the charlatan to make it appear that every mild disease is a dangerous one, so as to exaggerate the importance of his alleged "cures"; and he has, evidently, made free use of the popular fear of diphtheria, the past year, to serve his purpose.

In England, diphtheria is quite universally classed among the so-called "filth-diseases"—a name now enjoying quite a fashionable prominence. Many writers attribute its increase in that country, of late years, to the more general introduction of sewers during the same time, and have no hesitation in assigning sewer-gases as its chief cause. This general opinion is well expressed in the following extract from a report on the health of Tottenham in 1875:—

"There were twelve deaths from diphtheria,—a great many too many, though four fewer than last year. This, too, is a filth-disease, and is believed to arise in almost every case from foul air within houses themselves. There has been scarcely a case of diphtheria in Tottenham, in a house where some serious defect in the house-drains was not discovered. That diphtheria nearly always arises from want of pure air within the house itself, is also shown by the fact that out of the forty-seven deaths from diphtheria in Tottenham during the last four years, only seven occurred during the five months, May—September, when, of course, windows and doors are kept open. On the other hand, during the coldest three months in the year, December, January and February, when houses get but little fresh air, and when also, owing to the much higher temperature within doors, sewer-gas forces its way in through unventilated drains and defective traps, there were twenty-five deaths, as compared with only twenty-two during the remaining nine months of the four years."

This statement is not fully borne out by experience in Massachusetts during the past year. The disease has not, as a rule, prevailed during the warm months; but in those towns where its fatality has been the heaviest, there have been no water-closets used, and the closing of the windows could not expose the occupants of the houses to any greater

concentration of sewer-gases. Our correspondents place the element of contagion very high in the causation of diphtheria. From the 204 reports, there are many cases given which give strong support to this theory, although it cannot be said to be true to the same degree that it is of small-pox, measles, and scarlet fever.

That so many cases were exposed without contracting the disease, would apparently imply that something more is needed than the mere exposure to the poison. In one town, for instance, two very severe cases, both fatal, were imported from Canada; and although no care was taken to prevent such a result, there was no spread of the disease, and not another case occurred in that town during the year. One of our correspondents observed that the disease had been communicated in a violent form to those who "laid out" bodies of persons having died of diphtheria.

From Pittsfield, Royalston, and Lanesborough, especially, the evidence is strong that the disease is also infectious.

Exposure to cold and damp is given as at least an important predisposing cause. In this connection, it is proper to speak of the privies of many of our public schools and dwelling-houses in terms of the strongest reprobation.

Bad drainage is thought by most of our correspondents to be associated with diphtheria in the immense majority of cases, or that its greatest severity is reached in badly-drained localities; *i. e.*, where the soil is not or has not been properly dried, an evil which may obtain on high as well as on low land. This, however, is not thought sufficient of itself alone. Many low-lying and wet towns, where drainage of the soil is very imperfect, even where, too, a water-supply has been introduced without sewers for its proper removal, have been rarely visited with the disease, and then only lightly. We have no means, however, of knowing what the result might be if such towns were exposed to the virus of the disease in a concentrated form.

Filth, although not so evidently connected with diphtheria as with typhoid fever, diarrhœa, and dysentery, plays an important part in its causation, especially when associated with dampness. In some of the towns, the contamination of drinking-water with filth has appeared to be at least partially at

fault; in a few cases, the evidence is quite strong as to its being, if no more, a cause of unusual severity in symptoms or of more extended prevalence. In Holyoke, the proximity of water-closets to sleeping-apartments was suspected, as being the chief insanitary condition observed in connection with the disease.

In a certain proportion of cases, the conditions were supposed to be wholly atmospheric.

Some of our correspondents, finding no other constant cause, are inclined to attribute the prevalence of diphtheria very largely to individual predisposition. A few again find no difference in age, sex, locality, etc., and are utterly at a loss to account for their cases. In Worcester and Millbury, where the Blackstone River is fouled so extensively by sewage from houses and manufactories, but where the soil is for the most part dry, very few cases occurred. In Boston, Woburn, Lynn, and Salem, however, where the sewage is offensive and the soil wet, the disease was quite prevalent. In New Bedford, of a very severe epidemic, few cases occurred where the sewers had been built and in use. Of thirty-eight deaths in that city, eleven occurred among the pupils of one school, where there was no ventilation except from opening the windows, and where there were two privies just outside the walls of the building. Both of these causes of exposure to young children *indicate a recklessness or ignorance in regard to their health which can hardly be called less than criminal.*

Diphtheria has been unusually prevalent in Wakefield; but our correspondent, a careful observer, finds no explanation for it. Many of his cases occurred in damp localities. On the Merrimack River, Lowell, Lawrence, and Haverhill suffered considerably. From Boston as a centre, the disease is to be traced along the Charles and Mystic rivers to some distance, and lying largely between the two.

In the northern and north-western parts of Essex and Middlesex counties, the disease was, in most cases, mild, or not largely prevalent.

From New Bedford, where there was a severe epidemic a year ago, the disease can be apparently followed northward to Taunton and Walpole, and easterly through the southern towns of Plymouth County, to the western ones of Barnsta-

ble. In Yarmouth there was a severe epidemic, but quite local. Beyond that town, the disease is reported as not occurring, or very rare. The soil on the Cape is gravelly and dry.

In Norfolk and Worcester counties, the epidemic for the most part fell lightly, the cases having been generally sporadic. In Westborough and Leicester, diphtheria was prevalent. In the northern part of Royalston, a small, unsewered town, the mortality was excessive, twelve deaths having occurred out of twenty cases, every one of which was thought by our correspondent to be traceable to contagion; the adjoining towns of Winchendon, Phillipston, Athol, Orange, and Warwick escaped entirely, or nearly so.

In the lower part of the Connecticut Valley, West Springfield alone suffered severely, although cases occurred in Longmeadow, Springfield, Holyoke, Westfield (prevalent), and Easthampton. Northampton escaped almost entirely, while a number of severe cases occurred at Hadley, across the river.

The disease prevailed with the greatest malignancy in the northern and western parts of the State, where the population is as largely American as anywhere, the land high but often moist, and drainage almost entirely left to nature. In Williamstown and Adams, the epidemic fell heavily. Following down the valley of the Deerfield River, Florida, Heath, Charlemont, Leyden, Shelburne, Conway, Greenfield, Deerfield, Bernardston, and, east of the Connecticut River, Montague and Northfield, suffered severely. Rowe, Hawley, and Buckland escaped with less prevalence and fatality. In some of these towns, the epidemic was nearly over by the beginning of 1875.

In Berkshire County, thirteen out of the fourteen towns heard from report cases of diphtheria; except in its northern section, however, the disease does not appear to have been very prevalent.

In those towns throughout the State where especial prevalence or severity of the disease has been marked, there are no sewers; in only a few of them are there any water-closets; and the gases from decomposing organic matter have no opportunity to reach the insides of the houses, unless, possibly, from vegetables stored in the cellars. That is to say, the

disease has been for the most part one of the unsewered towns; in the cities where there are sewers, it has been most prevalent, or entirely so, in those parts which are badly drained or have no sewers. An exception must be mentioned in this respect, however, with regard to a few cases in the best houses in Holyoke.

The mortality in some of these towns was excessive; namely, from sixteen to fifty, or even seventy-five, per cent. of the cases attacked. In Conway, where there is a large Irish population, the Americans were almost the only ones attacked; and one-tenth of the native population suffered from the disease, of whom thirty per cent. died. The foreign population escaped almost entirely, although living in a condition of filth not seen in the houses of their less fortunate fellow-townsmen.

In Greenfield, especially, the disease was chiefly met in very low and wet localities; in Florida and Adams, it was most prevalent on high land,* and largely among foreigners.

One fact is impressed on us with great force,—that the disease is primarily connected with decidedly insanitary conditions; but that, after a certain degree of concentration of the poison has been reached among those living under bad hygienic circumstances, the best attention to sanitary law will not in all cases protect the more fortunate part of the community who reside in the best parts of towns and cities.

The conclusions at which we have arrived from the facts reported to us by our correspondents, are as follows:—

I. That diphtheria is contagious, and may be under certain circumstances highly so.

II. That it is also infectious, although not to so great a degree as scarlet fever, measles, and small-pox.

III. That, where other circumstances assist, its spread is promoted by dampness or moisture of soil, whether naturally existing or produced, especially with a tough, impervious sub-soil.

IV. That the special connection between this disease and

* The soil is quite shallow, overlying rock. Our correspondent thinks that diphtheria prevailed more extensively on the western than on the eastern slope of the Hoosac range.

filth is not so clearly made out; although such a condition would undoubtedly aggravate the bad effects of moisture alone. The subjects of contamination of well-water by human filth, and of the air of sleeping-apartments by sewer-gases, as predisposing causes of the disease, deserve more careful study in the future; our returns do not at present give us sufficient data for the expression of a positive opinion. Some of our correspondents suspected the introduction into the system through drinking-water of some septic influence which gave rise to the disease.

V. That exposure to dampness and cold, especially among children and those otherwise predisposed to the disease, tends to induce diphtheria.

VI. That Americans and foreigners in Massachusetts have been about equally subject to the disease, other matters than that of nationality being equal.

VII. That individual or family proclivity, age, and depression of the vital powers from any cause whatever are important factors in inducing this disease (as well as others) more rapidly and in a more fatal form, when other causes are also in some degree present.

VIII. That there is also some atmospheric condition, of which little is now known, the presence of which, even if not necessary, is at least important in the causation of diphtheria.

Extracts from Letters received from our Correspondents in regard to Diphtheria.

Amesbury.—I have known of no cases during the past year where the sanitary conditions of the houses, etc., were at fault. The worst cases previously in my practice occurred in families well off, of good judgment, intending to take the very best care of their children. The constitutions of the children were at fault,—the mother of one dying of consumption soon after the child's birth; another never having been a "rugged" boy; others belonged to a family in which the children all die young.

Amherst.—Two of these cases were in perfectly healthy localities. The Irish family in which were the other four cases live in a neat, small house, nearly new, on a dry, sandy, and gravelly knoll, one hundred rods from any other dwelling, cellar dry enough to keep shavings, the whole house and surroundings neat and cleanly. Only two possible causes occur to me: one, the fact that the family of six slept in one small bedroom, 6 by 8 feet; and the other, that within fifty rods runs a small stream that, before it passes the house, drains a region of Irish and American tenements, taking the wash from the same, and opposite the house opening out into a small pond.

Arlington.—I have seen very little diphtheria, though the sore throats have taken on a diphtheritic type; the cases have been sporadic,—some among the best hygienic circumstances, and some in the most unfavorable.

Ashburnham.—There have been numerous cases of tonsillitis, with copious patches of lymph on tonsils, palate, etc., but none of diphtheria.

Ashby.—Diphtheria has never prevailed in this town as an epidemic, or at least not for the past ten years, although every year brings a few cases.

Attleborough.—Diphtheria prevails here in all varieties of soil and hygienic condition, severest among children of lymphatic temperament.

Barnstable.—So far as I know, there have been but two fatal cases during the year; they occurred within about two hundred rods of a slaughter-house, and the question arose as to the probable influence of the same,—*doubtful*. The rest of the family had diphtheritic sore throat.

Bedford.—There has been no case of decided diphtheritic inflammation; but the tendency to inflammation of the throat, with constitutional symptoms in excess of local lesion, has been somewhat prominent. I have not been able to connect these phenomena with any local cause.

Belchertown.—No case of diphtheria has occurred for the last five years. About sixteen years ago, we had a large number, and several fatal cases; and five years ago I had seven cases in one family—two fatal; but it did not extend from this house, and I have had no cases since.

Berkley.—It seems to me to prevail more in wet locations. I do not know that any other circumstances have much effect. I might say that there are several locations in Berkley where I think the water is not good. . . . A school-house and privy have been very recently built; the school-house has been used only two terms—the privy very little used. The situation of the privy is on the side of a hill, near the base, about eight feet higher than the spring (used for drinking), and eight feet east of it, the water-courses running in the direction from the privy to the spring.

Beverly.—The following is an account of eight cases of diphtheria in a family of ten, which occurred in my practice in Beverly, last July, and which appeared to be due to a specific origin. The family live in a one and a half story house, eighteen feet square, containing three small rooms on each floor. There is no cellar, the house resting upon the lower border of a rocky ledge, which is mostly bare, cut by numerous deep fissures, and only in small spots covered with a few inches of soil. The ledge rises with a sharp inclination from the eastern side of the house for about fourteen feet, where there is a small level spot, upon which was located, until the second week in June, a wooden privy, resting upon a brick wall. The vault had a depth of a foot and a half below the surface-soil (which was deeper here than upon the slope), the bottom being the ledge, which dipped slightly in the direction of the house. The occupant of the house said that he was particular to have the vault cleaned out twice a year, and also that he occasionally threw down ashes and dry earth. Early in June, the house covering the vault was moved from its position on the south-east corner to the south-west corner of the yard, at the request of a gentleman who found the privy to be in too close prox-

imity to his own new house, then being built upon a higher part of the ledge, about forty feet away. The new location of the privy is about the same distance from the house as the old one. The vault was uncovered only for a few hours, the contents were not removed, and the hole was filled with earth. Early in July, I was called to visit a member of the family. The patient, an infant, always had been a sickly child, had had convulsions at various times, a similar attack being the occasion of my attendance.

While in the house, I learned that four of the children were troubled with sore throat, the first case of which had appeared about three weeks after the removal of the privy, the other three following with intervals of only a few days. As the symptoms were all slight, the parents were not alarmed, but treated them themselves. July 28th, I was called to attend one of the sons, ten years old, who had been sick with "diphtheritic" sore throat for four days, but not so severely as to alarm the parents until the morning of the 28th. The child sank rapidly, and died early in the morning of the 29th. In about ten days, as I am informed by the mother, two more children and the father were sick with sore throat, but not seriously. In all, there were eight members of a family of ten, who had diphtheria in a mild form (with the exception of the one who died), in a period extending from the last week in June to the second week in August. There were no other cases of diphtheria in the neighborhood at the time, nor had there been any for five months, and I could learn of no other cases in town; and, although the house is in a thickly populated street, no cases followed the outbreak in that house. The question arose, Did these cases owe their origin to local miasm? With the view of solving this question, I investigated the premises carefully, with the following result: I could discover no unpleasant smell in any part of the house; I could find nothing in the fissures of the rock indicating escape of matter from the closed vault; nor could I learn that there had been any appearance of leakage, either before or after the vault was filled in, though it seems possible that the filling in of the unemptied hole may have forced some of the contents through the slight covering of earth, in which case it would run down toward the house. In a small room, opening directly from the kitchen, was the sink, the drain-pipe of which opened within two or three feet of the north side of the house. The ground near the outlet of the sink was wet, but I could not discover whether there was any leakage directly under the floor, as it will be remembered that there is no cellar. The tenant stated that dish-water sometimes was thrown into the sink; but usually the slops of all kinds were thrown into the vault. I think that the condition of the privy and the sink combined was sufficient to account for the outbreak. The drainage from the privy was directly toward the house; the house has no cellar, and any leakage from the sink must accumulate either under or in close proximity to the house, for it could not flow through the ledge on which the house rested; if the drainage from the vault mingled with the sink-water, it multiplied the possibilities of miasm; the effluvia from the privy must have contaminated the air in and about a house only fourteen feet distant; the season of the year is the most favorable for rapid decomposition of organic material. These are sufficient reasons, it seems to me, for attributing the first cases, at any rate, to local miasmatic causes. Were the other cases the result of personal contagion, or due to the same cause? Had the fifth child taken the disease from the other children, it is probable that, taking into account the number of occupants of such a small house, the manifestation of symptoms would not have been delayed from the 8th to the 24th of the

month; and similarly with the last cases, which, I am informed, did not appear for ten days after the fatal issue of the fifth case. If my supposition as to the origin of these cases is correct, it simply shows that the signs of defective drainage may not be striking enough to attract attention until we are led to investigate the causes of an apparently unaccountable outbreak of zymotic disease.

Blackstone.—A few years ago, two children were brought here from Canada sick with the disease, and died of it in a few days. No others had it in town at that time or subsequently.

Blandford.—There has been no diphtheria during the past year, and very little since 1863. Then it prevailed as an epidemic, with much severity. The localities where it occurred are high and dry, with no known exciting cause.

Brewster.—In July, diphtheria broke out in a family consisting of a mother and four children, the father being absent on a fishing voyage. The disease was contracted, undoubtedly, from a visitor,—a child from Yarmouth, who had not fully recovered from a sore throat, at the time not supposed to be diphtheria. Three of the children died; the fourth recovered. The house in which the family resided being situated near the sea-shore, remote from any other, the disease did not spread.

Brighton.—Diphtheria commenced in June, and lasted for more than a month; it reappeared in September, and has continued since, occasional cases arising now. As to the cause, I am not satisfied in my own mind. Most of the cases were among the poorer classes, living in tenement-houses, and overcrowded.

Brimfield.—All the cases of diphtheria I have ever seen have, I think, been traceable to bad surroundings; namely, sinks, privies, or damp rooms. My own experience is, that typhoid fever, diphtheria, and erysipelas, especially the former, are always associated with bad surroundings.

Brookfield.—I have not supposed what little of the disease we have had could be attributed to any surroundings or particular locality.

Cambridge.—We have had no serious epidemics of this disease. The few cases I have seen included various nationalities, both sexes, and the patients were nearly all under thirty years of age. . . . Generally the hygienic surroundings were bad, the drainage being defective, the cellars damp and filthy, and offensive smells abounding; but sometimes cases have occurred in well-appointed houses, where no cause could be found for the existence of the disease. A large majority of the cases occurred where the sewerage was not satisfactory.

Charlestown.—In every case of which I have been personally cognizant, there has been found, upon examination, defective drainage.

Charlemont.—The forty cases occurring in Buckland, Charlemont, and Florida were within fifty feet of the river level; many of the cellars were damp, and some of the tenements too much overcrowded.

Chelsea.—We have had some diphtheria, hardly an epidemic. My suggestions are, better drainage for the city, more attention to the ventilation of cellars, less occupation of basements as sleeping-rooms.

Chilmark.—About twenty years ago, I met with several cases of diphtheria of great severity. They were the first cases I ever saw, and I might almost say my only ones. They occurred in two contiguous farm-houses, located on damp, heavy soil, with an underlying stratum of white clay. One of the cellars was habitually wet. Both families were in good circumstances, and their houses and surroundings clean and comfortable. . . . There were four cases in one house and three in the other. A young man who lived a mile from them, and was a frequent visitor at one of the houses, contracted the disease, and came near dying.

Clinton.—All localities were apparently invaded, high and low, wet and dry; where the hygienic surroundings were satisfactory, and the contrary. In one family, five had sore throats with fever and prostration; the drains gave off an abominable stench; in no other case did I find anything to give offence. Soil, clayey; subsoil, "hard-pan"; water-supply from wells.

Dartmouth.—The disease was confined almost entirely to Dartmouth Centre, which is a low country, surrounded on all sides by hills. Ten of the twelve patients seen by me attended the village school, which is situated in a very low, swampy place, so much so that flag grows in the yard.

Dennis.—I have had but two cases of diphtheria, and both came from Gloucester. . . . I think diphtheria seldom prevails to any alarming extent on a purely sandy soil. . . . I have practised medicine in this locality for twenty-three years, and never saw in my practice more than about six cases.

Dover.—We have a sparse population, with a large proportion of high land. The flat lands are gravelly and light. In 1862-63 the winter was mild; diphtheria broke out suddenly, the first case being in a child of six years, and fatal. This disease pursued a capricious course, passing up a long street, skipping one house and taking the next, one out of a family, and then every member. . . . No endemic causes seemed to have any influence; the disease seemed in the atmosphere, and was apparently in no instance communicated from one person to another.

East Boston.—Among the foreign population, living on the made land and upon the uplands where there are no sewers, diphtheria and scarlet fever have been quite prevalent and fatal within the past two months, more or less. I have not had a large number of cases of diphtheria under my care. In every severe case that I have seen, there have been imperfections in the drainage.

Falmouth.—Diphtheria appeared to me to be contagious; one patient coming from out of the village was taken with it. A sister soon after came down, and then the nurse. All three died. Several others in the family suffered with severe sore throats. The nearest neighbors also contracted the disease, but none others in the village. During the present fall it has, so far as known, been confined to three families (neighbors).

Fitchburg.—No portion of the city has been exempt from cases of the disease, but they have been more numerous in some localities than others. This is especially true of the low lands bordering upon the Nashua River, in the southern part of the city. Other than location, the hygienic conditions are not especially unfavorable. The soil is light and sandy, and the subsoil a coarse gravel.

Gloucester.—Some cases occurred in elevated, dry positions, well drained, etc.; others in low, wet situations.

Great Barrington.—The cases occurred in instances where the dwellings were old, and decayed timbers were under them, or rooms were built without cellars under them, or the drainage was badly arranged about the houses. Dampness and foul air had their influence in every case.

Hadley.—In December, six cases of the disease occurred in a family which kept a rum-hole of the lowest class. All the surroundings were of the filthiest possible character; dirt in the house; tobacco hung in a shed, close by the kitchen; garbage all about; personal uncleanness and irregular life,—all conspired to entice disease. Water for drinking and cooking was taken from a well close on the border of the barnyard, which had a half-dozen pigs in it. There had been no known exposure to the disease. Four children died within a few days of each other; then a hired man, intemperate, but vigorous, aged thirty, followed. The sixth case, a young married woman, was removed soon after being taken, and recovered. An American, intemperate, from North Hadley, called in to see the family, was taken with the disease, and died in three or four days. This man's mother had it afterwards, and died. An Irish neighbor, a half-mile distant, visited the family, and had the disease immediately, but recovered; a child of his died of it a few days after. Soon, some five or six cases occurred in American families, but it was mild. These lived a mile away. Since then, within a week, one Irish child, who lived two miles off, has died. . . . With regard to the house especially mentioned, I would say that it is shaded very much, and the cellar must be filthy; but the situation is good, the soil being about two feet of loam with a subsoil of sand.

Hanson.—Until within a week, it has been confined to one part of the town, almost wholly on one street, which runs north and south, and along which the land is low. This is always the most unhealthy part of the town. Seven died, out of sixty cases.

Hardwick.—There was nothing to lead me to believe that the patients' surroundings had anything to do with the disease, any more than it has at all farm-houses. They are nearly all alike in this vicinity. The drainage from the sinks is usually upon the surface; the wells and privies are in juxtaposition, with the hog-pen not far removed; the sleeping and living rooms are all poorly ventilated, the cellars without any ventilation whatever; some never see the light of the sun.

Hatfield.—Localities invaded, wet; origin, I do not know; circumstances good; surroundings of the patients healthy; living-rooms airy and well-ventilated; cellars wet, not sunny; sinks empty on the surface; privies on the surface; soil rather wet, most of it subsoil clay; drainage poor; sewerage, none; water-supply good.

Haverhill.—During the month of November an epidemic broke out with some violence in Mount Washington, so called, an elevated, sandy region of the city, rather sparsely populated; about a dozen cases occurred. . . . The houses were new and well drained. Being in a sandy bed, the cellars were dry. Most of the children attend school in a large, new and fine building, located near a swamp, formed by the drainage of Silver Hill. A large deposit is held in the basin, and the question has been raised, To what extent can the disease be traced to this condition? The drinking-water of the school-house is pumped from the river, without much filtering; the houses are mostly supplied by the Haverhill aqueduct, from ponds. We have good sewerage in many parts of the city. The Irish population has been largely exempt from the disease. The portion of the city most thickly populated by the Irish is most defective in drainage.

Heath.—Sixteen years ago, the disease prevailed very extensively. I had over one hundred cases in one year, and lost ten per cent. of them. This was in the towns of Heath, Halifax, Whitingham, Readsborough, and Rowe; since then it has prevailed more or less every year. I cannot give any cause as to the disease.

Holyoke.—The disease has invaded all parts of the city, high and low, wet and dry, and about equally. It has invaded the well-constructed, elegantly furnished, and thoroughly ventilated homes of the wealthy and the cultured nearly or quite as often as the ill-constructed, meanly furnished, and poorly ventilated hovels of the poor and ignorant. It is a question in my own mind whether the modern water-closet, located, as it often is, in close proximity to the family sleeping apartments, is not a fruitful source of this and other diseases of a typhoid type. At least, I oftener meet with it in houses possessed of these so-called modern conveniences, than elsewhere.

Hudson.—Most of the cases have been on low land with imperfect sewerage, and, in some cases, privies not properly attended to; soil damp; living-rooms on the north side of house; water-supply good.

Hyde Park.—High land and low, wet and dry, have presented cases; but a large portion of our high land is filled with springs, which render cellars and contiguous land wet and damp constantly.

Lawrence.—It prevailed in all parts of the city; but the cases which I saw were, for the most part, in localities where the patients were exposed to dampness, as in rooms over wet cellars, or where there was little sunny exposure, and, perhaps, imperfect sewerage. Many cases, however, did not come within this description. Some cases were school-girls, who, having perhaps a peculiar susceptibility to the disease, were attacked after exposure to wet. Unquestionably, the want of good sewerage, and the emptying of sewage on the ground around houses and in back alleys, have been the occasion of some cases of diphtheria during the year. At any rate, the condition and the disease coëxisted frequently.

Leicester.—The family attacked lived under an old church where the rooms were low and dark. The sinks and privies both drained into the well. . . . At the wake following the death of one of the children, five young servants living in the village stopped over night; two had diphtheria, two slow

fever, and the fifth had high fever and profuse diarrhœa. The family moved to another tenement. There were no other cases in town.

Littleton.—All cases occurred in dry, sunny, good houses, and with well-to-do families. No supposed origin.

Malden.—A number of cases have occurred in a small settlement, situated upon a very considerable elevation, numbering some twenty houses. This hill, a rocky eminence, has a fine natural drainage; but there is no depth of soil above the rocky substratum, and no system of common sewers, so that the thin layer of earth into which the privies and cesspools necessarily empty, soon gets saturated. Diphtheria may be said to be endemic in this locality.

Marshfield.—There were three cases in one family this year, and no others; they made their appearance simultaneously, and occurred in a wet, marshy place. The family had recently come from Boston Highlands.

Montague.—The cases that occurred in February and March were mostly on low land, though not wet or marshy; those in September were on higher ground, dry, light soil and gravelly subsoil.

Nantucket.—I could not account for the prevalence of the epidemic (of 1860). It came, as influenza has come here more than once, affecting many persons; but it was not influenza. Some cases occurred, where dampness of the soil and locality might have had an influence. The water here is good, but it is very possible that some of it may be injured by the vicinity of privies and drains to the wells. The town is compact, and, as the soil is sandy, water soaks away quickly, and but little thought has been given as to where offensive liquids go, so that they get out of sight and smell. Since 1860 the disease has not prevailed here, nor did it for fifteen years previous to that time.

Natick.—An open drain receives the wash and sewage from Walnut Hill. It is also a receptacle for dead cats, rats, and other useful animals. Standing upon the edge of this, a biscuit could be tossed into the beds where were sixteen cases of typhoid fever and dysentery of a typhoid type, the exact proportion of which were fatal I cannot say; but there were several deaths. This drain is a natural estuary of Pegan Brook, and all this filth goes into Lake Cochituate, especially after a rain. Diphtheria did not, in any case, seem endemic here; but prevailed in damp, open weather in winter and spring. It does not seem to have been influenced by any discoverable local cause, and was as often fatal in a high, airy, sunny locality as in a low hovel.

Needham.—My two cases occurred in the houses of wealthy people, situated on the south side of a hill. The cellars are more or less moist in consequence of the rocky soil and being on the side of a hill.

Newton.—The cases under my care in August were on very low ground on the banks of the Charles River, only a few feet above high water, in old houses with bad surroundings, soil wet, of course; two others in adjoining houses—equally bad, if not worse. The case I saw in winter was in a good

neighborhood on a gentleman's place, but the air was bad from the neighborhood of stables, etc.

Newton Lower Falls.—There have been seven cases of diphtheria, six fatal; three adults, three children. Two of the cases were in an old tenement-house, near the river, on a hillside on a corner. The house was not in a very bad condition, but the well was where a good deal of surface and sink water ran into it. The well, an open one, was close to the house in the angle between the L and main house. The privies were about forty feet from the well, but the vaults were not close. In this house two children died; there were no other cases in it. Two other cases were on the Needham side of the river, in a small story and a half house and shop, together. The house was clean, with good cellar, faced the south, and was quite open on three sides. Nothing about it to be noticed. The water came from an old well on the roadside some distance from the house and some distance from privies. This first case was of a barber and harness-maker, who died; then his sister was taken sick and died.

The other three cases were on a side street in a comfortable, well-to-do family, living in a small story and a half cottage-house, on high ground back from the street, plenty of room all about the place. The well, however, was on one side of the L, the privy opposite it across the L, not more than twelve feet apart. The sink-spout ran back some distance in the garden. The vault to the privy was not a close one. The first case here was a child of eight, who died, then the aunt, and now the mother is quite ill.

North Adams.—I am not a believer in the contagiousness of diphtheria; and, from my observations of this disease, I cannot lodge it or find its hiding-place, or the causes that develop it; for the past two years I have hardly been free from cases. One fact, I think, is established in this region: that high elevations are more subject, and with greater fatality.

North Reading.—Since the great epidemic of diphtheria, ten years ago, people are apt to call every sore throat by that name. I have not seen a well-marked case during the last eight years.

Orange.—In 1848 the disease first made its appearance; from that time it has occasionally cropped out in sporadic cases, and occasionally as an epidemic. From 1862 to 1865 it prevailed epidemically throughout this region, and at times was quite fatal. Since that time the disease has occasionally appeared, but mostly of a mild character. During the past year there have been quite a number of cases, most of which were mild. I do not know that any localities have been entirely exempt from the disease during its greatest prevalence and severity; those living on high land have suffered alike with those on low land, and such as lived on dry, light land as well as those on moist, heavy land. I will not attempt to account for the appearance of the disease; being so wide-spread and general in its prevalence, it is difficult to arrive at any satisfactory explanation of its cause. If close living-rooms, damp and dirty cellars, badly-cared-for privies and sinks, careless sewerage, etc., are productive of diphtheria, I should expect to see a perennial epidemic of the disease in some localities.

Orleans.—I have not seen a well-marked case of diphtheria during the year; cases of ordinary diseases of the throat are, in my opinion, often passed off for that disease, and generally with a motive.

Peabody.—I have not observed any peculiarly unfavorable conditions existing in the surroundings of the patients thus far treated by me for this disease.

Pembroke.—I have had thirteen cases in a recent epidemic at South Hanson. The location of my patients is a lane, running down to one of the Halifax ponds—a swamp on both sides of it; soil wet; drainage on the surface. The people are very poor, living huddled up in small houses.

Pepperell.—The cause could not be detected, as cases occurred both in elevated and low locations, among the most cleanly and refined people as well as the opposite. The cases of recovery, however, were uniformly among the former.

Pittsfield.—Of the forty-five fatal cases occurring during the last two years, not one has been in the best class of dwellings. The disease has been limited to the poorer class, and chiefly foreigners. The families generally lived in small, overheated rooms, poorly ventilated, and the children ran out into the open air improperly clad. The diet, too, was generally inferior. Sanitary defects outside the house could generally be found, but not always. The cases were scattered all over the town. The cellars were generally dry—few are otherwise here; water is the best; the houses sunny. The origin of the first cases in any family was generally obscure, but contagiousness was very marked in families, and frequently traced from house to house.

A very fatal but limited epidemic occurred in Lanesborough last summer. I think eight persons died, being nearly all that were attacked. It began in a family of extraordinary filthiness, in which the cases were most malignant. The other cases were neighbors who had been directly exposed to contagion. This epidemic, apparently, was carried from Pittsfield by infection.

Royalston.—This town has recently suffered from an epidemic of diphtheria, attended with alarming fatality. Of twenty patients attacked, twelve died. With the exception of the children, those subsequently attacked, after the first case, were those who had either watched with the sick or assisted in laying out the dead. The cases I visited were in healthy localities; drainage and sewerage good. I should judge, however, from what I can learn, that the conditions were quite the reverse in the house where the disease originated.

Another correspondent writes: "Each case, except the first, could be traced exactly to exposure to a previous one. Seven adults and five children died. A woman washed the linen of the first family on Tuesday, and died at six o'clock p. m. Thursday, of the same week."

Salem.—It can hardly be said that we have an epidemic of diphtheria, yet this disease is more wide-spread and frequent than it has been for many years. It has seemed to develop itself most easily in young children, yet it by no means infrequently attacked adults. Persons of both sexes, and of all nationalities, seem to be equally susceptible to its specific poison. We cannot find that one section of our city above another has been exempt from its visitations. Families in dwellings on high land, with good drainage, and whose method of living seemed conducive to health, have suffered from this disease in common with those living in damp, undrained, and filthy houses. The number of fatal cases of diphtheria has been comparatively

small. The disease has generally subsided in from five to ten days. It has been noticed that in families where well-characterized cases of diphtheria occurred, other members were at the same time affected with slighter inflammations of the throat. This we are inclined to regard, not as the effect of the diphtheritic poison, but as the result of the general hygienic surroundings or atmospheric conditions which favored development of diphtheria in the others. Associated with diphtheria, there has been a marked prevalence of various forms of sore throat. It may magnify the skill of a physician to persuade people that he has cured a patient of diphtheria in two or three days, when he has to deal only with a comparatively mild throat distemper; but he is likely to raise expectations which he will fail to satisfy when he is called to treat active manifestations of a true diphtheria. And worse than all, he is likely either to needlessly alarm some households on the one hand, or on the other to create the opinion that diphtheria is a trivial disease, which can be easily and quickly controlled. Such an underestimate of disease is likely to lead to fatal postponement or neglect of treatment. We cannot help noticing that during the last four months there has been a marked tendency to affections of the mucous membrane of the respiratory organs, since, together with bronchitis and pneumonia, we have had associated the prominence of laryngeal and bronchial symptoms in measles, and the throat symptoms of diphtheria. We have no data which as yet satisfactorily explain why diphtheria should appear at this season rather than formerly, or why it should distribute itself as it has.

Saugus.—The localities and surroundings in my cases have been all favorable to health. The supposed origin of the first cases was in a small party for boys and girls, where one of the number was already sick and afterwards died, several of the others being attacked within a few days.

Shelburne.—In one family where there were six cases, the house was well ventilated, the family neat and cleanly, the house on high land; but through the spring the soil around the house was saturated with moisture, and the cellar very wet and containing a large quantity of vegetables. In another family, where five cases occurred, the house stands on high and dry ground, well ventilated, with dry cellar. In each of these houses the light of the sun to the rooms is obstructed by piazzas.

South Hadley Falls.—Diphtheria has been most common and severe in that part of the Falls village which has lately been built upon a swamp, with miserable drainage, if any.

Southwick.—The cases were among farmers, in apparently healthy locations. The cellars are dry, and the living-rooms such as we find in most of our farm-houses. No sinks are used in the houses; but the wash-water is thrown out on the surface of the ground, near the wells from which water is obtained, where it may sink through the soil of sandy loam and gravelly subsoil to contaminate the water of wells.

Springfield.—Diphtheria has been limited to localities and isolated families, and evidently caused by dampness, bad water, defective drainage, no sewerage, and infection or contagion from carelessness in families while existing. It has, in many instances, been confounded with pharyngitis, tonsillitis, and follicular inflammation. Consequently, exaggerated statements of its prevalence have obtained.

Stoneham.—The two deaths referred to occurred on a hill with moderately good surroundings. A marshy piece of land lies on the foot of the hill a few rods distant; no drainage and no sewerage.

Another physician says, "Most of my cases of diphtheria occurred in families living on high ground, and I could find no hygienic circumstance looking toward the cause. I feel confident that after the first case in a family, the chief cause was contagion."

Taunton.—Causes of diphtheria here are dwellings in swamps, prevalence of north-east winds, with the air heavy, cold, and changeable, and the use of surface-water or swamp-water for domestic purposes.

Wakefield.—I have observed that wet and cold hillsides, *i. e.*, with northern and western exposure, have been rather the favorite habitats of diphtheritic attacks.

Wareham.—I should say that I had treated fifty or sixty cases in the last twelve years in this town and vicinity, with a loss of perhaps one-fifth, and about the same number of cases in the months of January, February, March, and April, 1861, in the town of Sterling, with a fatality of more than one-third. In this vicinity, all localities were invaded alike. I think the disease as contagious as scarlatina.

Watertown.—The cases that I have seen (not fatal) have occurred in houses which, in respect of sanitary matters, are fully equal to the average habitations of the middle and lower classes; none of them were tenement-houses with more than two families. The fatal cases of which I hear were in localities where the soil is moist and the drainage must be defective.

Webster.—The cases that have occurred here (sporadic) have appeared under all sorts of circumstances and conditions of life, and were not traceable to any particular condition.

Westborough.—The cases occurred in families with very comfortable surroundings, in sunny rooms, in two cases, with apparently good drainage; soil, a light loam, with sandy subsoil; water supplied from wells.

Westfield.—Surroundings of patients seem to have made but little difference here. Imperfect nutrition, and sudden changes of temperature of the body, seem to constitute the appreciable causes.

Westford.—Cases occur in this town more along the water-courses and on the low grounds; very rarely on the hill.

West Springfield.—The houses in which diphtheria occurred were in damp localities, occupied as tenements, of few rooms each, so that overcrowding was added to bad situation. The lower part of our town lies on low ground, protected by a dike from spring freshets. It has lately been rapidly built up with houses close together; a sewer opening below high water has been commenced, but from "economy" left uncompleted. There are few, if any, connections with houses. The soil is here alluvial, resting on quicksand; water is reached at a depth of about eighteen to twenty-five feet. The

houses are occupied mostly by railroad employés, not remarkably cleanly; and, what with the proximity of wells and privies, with kitchen-sewage generally conducted to a closed cesspool, necessarily not far from the house and well, everything seems ready for an epidemic when the soil in time gets sufficiently soaked or the necessary "germs" come this way.

Winchester.—I believe that the prolonged cold of last winter and early spring lowered the "tone" of health and diminished both the resisting and recuperative powers of the population. . . . One of my worst cases was over a wet cellar, in a springy and undrained meadow, but in an isolated house, in an unhealthy family of six. There was no other case in the family.

Worcester.—My cases have all occurred where there were no sewers, but the houses were not in bad hygienic condition.

The few reports following, although not relating to the subject of diphtheria, are inserted, as dealing with matters of considerable importance. The two cases of poisoning deserve general attention, the second of them with special reference to legislation, which is evidently required. No comment is needed on the sanitary condition of the camp, farther than has already been made by the surgeon-general.

Lowell.—On the afternoon of Sunday, December 12, three boys had been rambling in the fields on the line of the Concord River, not far from the Boston & Lowell Railroad bridge, when, becoming very hungry, they ate some cranberries which they found on their way. Afterwards, at about three and one-half o'clock, having come upon a potato field, formerly a meadow, and but recently dug up, they discovered some roots lying on the surface. Taking them to be carrots, the boys broke off some pieces, and eagerly devoured them.

Two of the lads (they were about fifteen years old) went home, and in about half an hour after leaving the potato-field were found, each on the ground, in convulsions. There was, in each case, a feeble attempt, at first, at vomiting, but with scarcely any result. The convulsions quickly became more severe, and death ensued in an hour after.

The third boy, who says he had eaten three of the tubers about to be described, having heard of the critical situation of his comrades, became alarmed and ran home, a distance of about a mile, where he arrived at twenty minutes of five. On the way he felt a little dizzy, and the "taste of the root he had eaten kept rising in his throat." On entering the house, he told his mother he was sick and wanted to vomit, drank half a cup of an infusion of lobelia that had been prepared for his sick father, then some warm water, and in a very few minutes threw up a large quantity of the so-called pieces of carrot, together with some cranberries, a part of which were undigested. He immediately staggered and stiffened out in convulsions. In a short time he came out of the fit and then lay pale and exhausted. Whiskey was largely administered. Convalescence began in six hours, and in forty-eight he was well.

The root with which these boys were poisoned belongs, according to the botanists, to the *cicuta maculata*, a perennial plant commonly called American

hemlock, spotted cowbane, etc., and is probably the most poisonous of our vegetables. There is an excellent description of the plant, with a colored engraving of the upper part of it, in the first volume of Bigelow's Medical Botany, where also are given cases of poisoning with symptoms similar to those just described.

The plant itself reaches its growth in midsummer, when it presents quite a conspicuous appearance in our wet meadows, grows to the height of a man's head, bears a green, parsnip-like, serrated foliage, and bears at the summit of its branches clusters of minute white flowers, like those of the carrot, parsnip, etc. The stem is often spotted or maculated, hence the specific name of *maculata*. But the general appearance of this plant is apt to be confounded by the unbotanical eye, with other members of the family of *umbelliferae* to which it belongs. The distinguishing feature is the root, which is composed of a number of large, fleshy tubers that are attached to the central stalk, like the root-growths of the dahlia, and bear a general resemblance to fingers in size and shape.

During the growth of the plant the fluids are, of course, distributed throughout the entire structure; but, after the stem performs its office and decays in the fall, the juices accumulate in the root. The poisonous principle consists of a yellowish juice stored up in the cortical portion. The central part of the root is a white, mealy pith. When a tuber is gently pressed, the yellowish juice oozes out in resinous, glistening drops, and emits a pungent, aromatic odor, somewhat like that of parsley or celery, which, together with coriander, anise, lovage, etc., belong to the same family.

During the past year, the statement was published that illness had been caused in a box-factory in Lowell, from the use of arsenical paper. The case was investigated by Dr. E. G. Cutler, of Boston, who made the following report:—

"Of a collection of seventeen girls who had worked some time at the trade, four have been variously sick; of these, three have ceased to work at the factory, while the fourth still remains, though temporarily absent. The details of these cases, so far as could be ascertained, are given below:

"*Case 1.* A young woman who had been at work at least a year, took sick of consumption; the disease ran its usual course, and ended fatally. Her disease was not attributed to her employment.

"*Case 2.* A young woman, previously healthy, after working some time, had a swelling on one finger, an eruption on her face, headache, nausea, pallor, and sore eyes. She attributed her illness to her employment, gave it up, and made a speedy recovery.

"*Case 3.* A young girl of eighteen, previously healthy, who had worked at least one year, and during that period was at times more or less ill, consulted her physician with the following condition of ill-health: General pallor of a marble-like color, universal swelling, languor, tendency to sleep, nausea more or less pronounced, occasional vomiting, headache, some intolerance of light, accelerated and feeble pulse, coldness of extremities, sluggish appetite, an anæmic heart murmur. She gave up the business, and made a speedy recovery under the use of simple remedies. She has not again resumed the work, and remains well.

"*Case 4.* The patient is now in a very low condition, from chronic disease of the kidneys. Her attending physician attributed her sickness to other causes than her employment.

"The manufactory was found to be in the second story of a wooden building, whose ground floor was occupied by a blacksmith. The work-room is seventy feet long, thirty feet wide, and eight feet high, lighted by fifteen windows, heated by three stoves, and well ventilated; in it work fifteen girls, from seventeen to twenty years of age, two men (the heads of the firm), another man and a boy. All were good-looking, strong, healthy people, above the average intelligence. The work is done at a counter, three feet high, which runs around the sides of the room. The girls have been in the same occupation for periods varying from two to seven years, and have all, without exception, had the average good health of young people of their age, occasionally absent for a day or two, but never for as much as a week at a time; all are graduates of the high school. The pasteboard for the boxes is cut and scored by machinery down stairs, brought up, bent into shape and glued by the man and boy, and given to the girls to be covered with the green or red paper used for this purpose. The red paper is a vermillion. The green an arsenical, known as Scheele's green, with sizing. An analysis of this paper, by Prof. W. R. Nichols, gave '8.96 grains metallic arsenic, or, if reckoned as white arsenic,—i. e., arsenious acid,—it would be 11.84 grains to the square foot.' The colored paper is cut to the proper shapes and sizes, at frames in the centre of the room. These strips are arranged in piles at the side of a girl, who applies to them a flour paste, and then sticks the paper on the box, smoothing the sides of the box and the top of the cover with a brush. In this process the fingers do not come in contact with the pigment. The sides of the cover are applied by the fingers, and in the smoothing process a certain amount of the green pigment is rubbed off on to the hands, which are washed at short intervals. A protector, with long sleeves, and high in the neck, is worn over the ordinary clothing. The mouth and nose are not covered by protectors. The green paper is kept in large covered packages in the work-room, to the extent of several hundred weight. There was scarcely any dust or dirt to be seen anywhere, except on the window-sashes where the hand brushed along gathered up a slight amount of dust, with a scarcely perceptible green tinge; also from the cutting-frames in the centre of the rooms, a dust, distinctly green, was rubbed off; this had no specially irritating property when inhaled. The amount was very small in each case. The hands and faces of the employées were free from eruptions of any kind, and their red cheeks and lips gave pretty good evidence of their good health, in addition to verbal assurances to that effect.

"In considering the cases above detailed, it is evident that two of the number can be directly traced to the arsenic; the symptoms are characteristic of the anæmia from this form of poisoning. Of the remaining two, a proper estimate of the effect of the poison in the causation or aggravation is impossible. The presumption, however, is, that it increased the effects of the disease. The fact that so small a number of cases of illness has occurred in an employment which deals with such a poison as arsenic, is striking, when compared with many other manufactories. Its cause is to be found in the great care which the employers have exercised for the comfort and health of their help, in the intelligence and tidiness of the latter, and in the fact that the paper is heavily sized."

Lynn.—The following table gives a few facts of interest with regard to the relation of sewers to disease in our city; although the facts are given for only one year, they are certainly very suggestive:—

DISEASE.	No. of deaths in 1875.	No. in streets containing sewers.	No. in streets containing no sewers.	Of uncertain residence.	No. per thousand of estimated population in streets containing sewers.	No. per thousand of estimated population in streets containing no sewers.
All causes (omitting still-births and violence), . .	617	106	489	22	12.84	19.75
Pneumonia, ...	41	3	37	1	.36	1.49
Scarlet fever, ...	57	6	43	3	.72	1.93
Typhoid fever, ...	21	6	15	—	.72	.60
Diphtheria, ...	11	2	8	1	.24	.32
Consumption, ...	118	21	92	5	2.51	3.71
Cholera infantum, ...	43	8	35	—	.97	1.41

The significance of the figures in this table is increased when we consider the following facts:—

1. The streets containing sewers compose the most densely populated parts of the city.

2. Many of these streets are among the most ill-conditioned in the city,* and they are largely occupied by a class of people who are careless of sanitary matters, and among whom the mortality is usually great.

3. The sewers have, for the most part, been constructed within a few years, and time has not been afforded for their full effect to be manifest.

The following insanitary condition of one of our camps for summer drill has already been reported† to the surgeon-general, and referred to in his report in no doubtful terms of condemnation:—

South Framingham.—The diseases, as usual, were principally diarrhœa and cholera morbus, beginning with a few cases, and increasing until, on Friday (the last full day in camp), the surgeons were busy the greater part of the day and evening. The cases were not serious, owing, no doubt, to the short time the camp lasted. Several reasons might be given for the sickness, such as change of habits, food, overcrowding, and bad ventilation of the tents; but the most obvious one, I think, is the poor quality of the drinking-water. The wells are about twenty (20) in number, four (4) being near the arsenal, and not much used by the soldiers; one is at brigade headquarters, a new curb-well, about eighteen feet deep. The others are scattered over the camp near where the cook-houses are generally erected, and not very far distant from where the sinks are dug; these are: six new stone, about sixteen feet deep; four wooden curb, eighteen to nineteen feet deep; four new brick, twenty to twenty-two feet deep; one old brick, fifteen feet deep.

* The estimate of the population of the sewered streets was made by the city engineer. It was 8,250, or one-fourth part of the whole, leaving about 24,750 for the remainder.

† The surgeon making the report has very kindly sent us these notes, and they are inserted with the permission of the surgeon-general.

The soil is gravelly, and after a heavy rain the ground is very soon dry; puddles six inches deep disappearing entirely in an hour's time after the rain has ceased falling. Each pump has a large wooden tub for the use of the men when washing. Last year (1874) the water came up soapy, as the tubs were emptied near the pumps; this was partially remedied this year by having the tubs removed eight to twelve feet from the pumps, and connected by a wooden trough.

There is no system of drainage to carry off the water and slops from the vicinity of the wells. The sinks are dug from two to three feet deep, in different places for each brigade, and without much regard to the proximity of the wells.

The water is no doubt all that could be desired, were it not so readily contaminated by the surface-drainage.

The state authorities are about putting up a fence around the campground, at an expense of about \$4,000. It is generally conceded that this money would be much better expended if used to grade and drain the land.

Population, estimated from the Census of 1875, and Death-rates in the Cities and larger Towns of the State, for the year 1875.

CITIES AND TOWNS.	Population.	Deaths per 1,000.	CITIES AND TOWNS.	Population.	Deaths per 1,000.
Boston, .	342,000	26.2	Peabody, .	8,060	21.3
Cambridge, .	50,000	22.4	Brookline, .	7,800	17.1
Lowell, .	49,688	20.5	Marblehead, .	7,677	25.4
Worcester, .	49,265	22.1	Natick, .	7,000	14.7
Fall River, .	45,340	26.2	Clinton, .	7,000	19.3
Lawrence, .	35,000	27.5	Plymouth, .	6,700	16.4
Lynn, .	32,600	20.8	Danvers, .	6,500	17.2
Springfield, .	31,050	21.4	Hyde Park, .	6,288	21.6
Salem, .	26,000	23.1	Amesbury, .	5,987	21.0
New Bedford, .	25,876	24.2	Southbridge, .	5,780	20.2
Somerville, .	22,000	22.7	Dedham, .	5,756	15.9
Taunton, .	20,429	21.1	Spencer, .	5,446	21.8
Chelsea, .	20,000	22.3	Wakefield, .	5,349	19.4
Gloucester, .	17,000	22.3*	Leominster, .	5,203	20.3
Holyoke, .	16,260	26.5†	Framingham, .	5,167	21.2
Adams, .	15,600	19.0	Westborough, .	5,140	19.4
Haverhill, .	14,700	16.3	Andover, .	5,100	18.6
Newburyport, .	13,323	23.1	Webster, .	5,059	18.3
Fitchburg, .	12,289	16.1	Middleboro', .	5,023	16.5
Pittsfield, .	12,255	22.5	Stoneham, .	4,984	18.4
Northampton, .	11,500	20.7	Stoughton, .	4,842	17.3
Malden, .	10,843	19.2	Hingham, .	4,654	20.6
Brockton, .	10,578	17.8	Provincetown, .	4,557	17.1
Waltham, .	10,000	17.5	Millbury, .	4,529	16.1
Weymouth, .	9,880	15.9	Hopkinton, .	4,503	22.8
Milford, .	9,800	20.2	Rockport, .	4,490	17.8
Woburn, .	9,568	21.8	Grafton, .	4,442	14.6
Attleborough, .	9,329	16.5	Barnstable, .	4,302	22.3
Quincy, .	9,142	19.4	Methuen, .	4,205	17.1
Westfield, .	8,429	17.0	Canton, .	4,192	11.9

* Excluding 123 lost at sea.

† Excluding 71 deaths by the fire.

*Estimated Population and Death-rates reported by the Registrars
of American Cities, for 1875.**

CITIES.	Population, (estimated.)	Deaths per 1,000 living.	CITIES.	Population, (estimated.)	Deaths per 1,000 living.
New York, .	1,053,819	29.10	Reading, .	40,000	21.62
Philadelphia, .	825,594	21.56	Paterson, .	38,898	29.28
Brooklyn, .	500,000	24.78	Lawrence, .	35,000	27.54
Chicago, .	420,000	18.80	Minneapolis, .	35,000	16.28
Baltimore, .	350,000	20.72	Quincy, .	35,000	15.60
Boston, .	342,000	26.18	Wilmington, .	35,000	24.45
Cincinnati, .	265,000	20.39	Atlanta, .	35,000	22.57
San Francisco, .	240,000	18.44	St. Paul, .	33,500	14.17
New Orleans, .	210,000	29.13	Lynn, .	32,600	20.82
Louisville, .	150,000	17.20	Springfield, .	31,050	21.44
Pittsburgh, .	140,000	21.12	Peoria, .	30,639	13.05
Detroit, .	116,000	19.70	Harrisburg, .	30,000	14.60
Providence, .	100,675	19.02	Wheeling, .	28,000	17.21
Richmond, .	72,639	21.84	Salem, .	26,000	23.10
Allegheny, .	67,000	12.70	New Bedford, .	25,876	24.20
Syracuse, .	60,000	18.55	Trenton, .	25,700	9.10
Charleston, .	56,540	32.97	Fort Wayne, .	25,000	17.52
New Haven, .	55,000	22.29	Dubuque, .	25,000	10.64
Cambridge, .	50,000	22.38	Bridgeport, .	25,000	13.92
Seranton, .	50,000	7.00	Terre Haute, .	25,000	13.88
Columbus, .	50,000	13.60	Norfolk, .	23,000	20.21
Toledo, .	50,000	16.18	Somerville, .	22,000	22.70
Memphis, .	50,000	23.06	Little Rock, .	20,475	16.01
Troy, .	50,000	10.00†	Poughkeepsie, .	20,080	26.29
Lowell, .	49,688	20.52	Taunton, .	20,469	21.07
Worcester, .	49,265	22.12	Denver, .	20,000	9.75
Fall River, .	45,340	26.17	Chelsea, .	20,000	22.25
Hartford, .	45,000	13.04	Springfield, Ill.,	20,000	16.85
Mobile, .	40,000	15.05	Augusta, Ga., .	20,000	20.70

* In some of these cities, registration of causes of death, or even of deaths, is not entirely satisfactory. Our last return from St. Louis is for 1874, when a death-rate of 14.45 was reported for an estimated population of 450,000.

† Given as "about" that rate.

The death-rate in London for 1875, with a population estimated in the middle of the year at 3,445,160, was 23.7. In "Greater London," as bounded by Sir Robert Peel, extending over the Metropolitan Police District and including the suburbs, the population, estimated by a satisfactory method, was 4,207,167; the total death-rate was 22.7, and *only 3.7 from zymotic diseases*. It is interesting to compare these rates with those of Boston.¹ No comment by us is necessary.

¹ See pp. 495 *et seq.*

